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NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

TRANSACTIONS.

VOL. XXXIV.

1884-85.

NEWCASTLE-UPON-TYNE: A. REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

1885.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

TRANSACTIONS.

VOL. XXXIV.

1884-85.

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NEWCASTLE-UPON-TYNE:

ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

ERRATA.

Page 102, line 18, omit the word "*imperial.*"
Page 139, lines 16 and 18, *for* "log. $a \times$ log. b," *read* "log. a + log b."

CONTENTS OF VOL. XXXIV.

	PAGE.
REPORT OF COUNCIL	vii
REPORT OF FINANCE COMMITTEE	x
TREASURER'S ACCOUNT	xii
ACCOUNT OF SUBSCRIPTIONS	xiv
GENERAL ACCOUNT	xvi
PATRONS	xvii
HONORARY AND LIFE MEMBERS	xviii
OFFICERS	xix
ORIGINAL MEMBERS	xx
ORDINARY MEMBERS	xxxi
ASSOCIATE MEMBERS	xxxii
STUDENTS	xxxvi
SUBSCRIBERS UNDER BYE-LAW 9	xxxviii
CHARTER	xxxix
BYE-LAWS	xlv
BAROMETER READINGS	309
INDEX	317
ABSTRACTS OF FOREIGN PAPERS, *end of Proceedings.*	

GENERAL MEETINGS.

1884. PAGE.

Oct. 11.—Paper "On the principles of Electric Lighting, and the construction and arrangement of Electric Light Apparatus," by Mr. Sydney F. Walker 3

Discussed 62

Dec. 13.—Paper, "Notes on the Coal-Fields and Coal-Mining operations in North Formosa (China)," by Mr. David Tyzack 67

Discussed 77

Paper, "Note on some Fossils from North Formosa collected by Mr. David Tyzack." by Professor G. A. Lebour 81

Paper, "Notes on the History of Mining in Cumberland and North Lancashire," by Mr. J. D. Kendall 83

Paper, "The Carboniferous Rocks of Cumberland and North Lancashire, or Furness," by Mr. J. D. Kendall 125

Paper "On a New Calculator for working out 'cost of working,' 'selling prices of coal' per ton, percentages, &c." 139

Note on the variation sometimes noticed in the difference of the simultaneous readings of two barometers, one at bank and the other in the workings of a mine 142

1885.

Feb. 14.—Paper "On the Manganese Deposit of the Islet of San Pietro, Sardinia," by Mr. Edward Halse, communicated by Professor G. A. Lebour ... 145

Paper, "Notes on Microscopic Sections of Rocks from San Pietro, Sardinia," by Mr. F. W. Rudler... 159

PAGE

Paper "On the Marsaut Lamp," by Mr. M. Walton Brown 161
Discussed 165
Discussion on Professor Lebour's paper "On the Breccia-Gashes of the Durham Coast" 167
Discussion on Mr. M. Walton Brown's paper "On the Observation of Earth-Shakes and Tremors" 168
April 11.—Paper "On the Shrinkage of Paper," by Mr. C. C. Leach 175
Paper "On the Routledge and Johnson Double Combination Miner's Safety-Lamp," by Mr. J. Routledge 183
Discussion on Mr. David Tyzack's paper, "Notes on the Coal-Fields and Coal-Mining operations in North Formosa 190
June 13.—Paper "On a New System of Coal-Getting, with Burnett's Patent Roller Mining Wedge and Nicking Machine," by Mr. W. J. Bird ... 193
Paper, "Account of the Experiments made at the König Colliery at Neunkirchen (Saarbrücken), particularly those on the consequences which arise when coal-dust and gas come in contact with shots; and other matters intimately connected with these experiments," translated by Mr. Theo. Wood Bunning 199
Discussed 245
June 30.—Excursion to the Hury Reservoir 255
Report by Mr. W. Gunn in reference to the works at the Hury Reservoir 255
Paper prepared and read by Mr. W. H. C. Stanford (Mr. Mansergh's chief assistant) on the occasion of cutting the first sod of the Hury Reservoir 258
Aug. 1.—Paper, "New Mining Regulations of Belgium, April 28, 1884." Translated by Mr. M. Walton Brown 265
Paper, "The Pieler Lamp, and modes of indicating the presence of small quantities of Fire-Damp in Mines," by Mr. Theo. Wood Bunning 285
Paper, "The Wolf Safety Lamp," by Mr. Theo. Wood Bunning ... 291
Paper, "Further Results of Experiments with Coal-Dust at Neunkirchen," translated by Mr. Theo. Wood Bunning 297
Discussion on the papers "On Experiments with Coal-Dust" 299

Report.

THE Council have pleasure in reporting that, notwithstanding the continued depression of trade, the affairs of the Institute are in a prosperous condition.

The contributions to the Transactions have been more than usually interesting. The first, by Mr. S. F. Walker, on Electrical Lighting, was prepared by that gentleman with the view of making it interesting and useful to mining engineers. He has succeeded in giving a clear and concise description of the electric light and the various modes of producing it.

Mr. David Tyzack has contributed a valuable paper on the Coal-fields and Coal-Mining Operations of North Formosa, China, which, having been read during the time of the French operations in that island, was received with special interest. Professor G. A. Lebour added to the value of the paper by giving some notes on the fossils which were collected in the island by Mr. Tyzack.

Mr. J. D. Kendall, to whom the Institute has been so often indebted for valuable geological and historical works connected with the mining industries and geological features of the North-West of England, contributed two excellent communications—the first on the History of Mining in Cumberland and North Lancashire, and the second on the Carboniferous Rocks of North Lancashire or Furness. The latter of these papers was admirably illustrated.

An interesting paper on a subject which for years has occupied the attention of mining engineers and of others who have to make plans on large sheets of paper, was contributed by Mr. C. C. Leach, who has, by means of diagrams, illustrated the various daily movements, together with the alterations in size occasioned in paper by the changes from day to night, from one temperature to another, and from damp to dry weather.

Safety lamps have also occupied the attention of the members; that invented by Messrs. Routledge & Johnson has been described by the former gentleman. Two German lamps have also been described. The Pieler lamp, which is especially adapted as a detector of gas, was used

advantageously in ascertaining the perfect diffusion of the gas in the several compartments of the gallery in which the Prussian experiments on coal-dust (hereinafter referred to) were tried. The other is the invention of Dr. Wolf, and exhibits the peculiarity of being able to be re-lighted, after it has gone out in a mine, without taking it to pieces, or in any way dangerously exposing the flame to contact with fire-damp. The Marsaut lamp has been described by Mr. M. Walton Brown.

A valuable geological paper, written by Mr. E. Halse was communicated by Professor Lebour, on the important Manganese Deposits of San Pietro, Sardinia. It was accompanied by notes on the microscopic sections of rocks from the district by Mr. W. F. Rudler.

The principal mechanical paper is one by Mr. W. J. Bird on a New Mode of Breaking Down Coal by means of a Wedge, its principle being that the friction of the wedge is diminished to a considerable extent by acting upon rollers instead of sliding against cheeks.

Your Council is giving its attention to the repeated occurrence of destructive explosions in coal-mines from causes the origin of many of which it is difficult to determine. Some of these accidents have occurred in collieries where every possible care has been taken to prevent them, and in pits where the amount of gas has been very limited and the ventilation good.

The theory that coal-dust may be an agent in intensifying explosions has long been before the Council, and some of the earliest experiments on its effects were made by members of this Institute. These experiments, it is true, were not on a sufficiently large scale, or so conclusive in their results as might have been desired, but they were sufficient to prove that coal-dust was an element of some danger. The Chesterfield and Derbyshire Institute confirmed what had been done in the Newcastle district by similar experiments at Chesterfield. Experiments were made at about the same time in France and elsewhere. Recently the German Government have taken the matter up on a scale suited to its importance, and your Transactions contain a translation by your Secretary, Mr. Bunning, of the very interesting experiments that have been made at Neunkirchen, which, together with the discussion thereon, may be considered to have brought this important question prominently before the members.

The German experiments seem to prove that the practical danger attached to the dust only, is small, and show that explosions of coal-dust can only be caused by "blown-out shots" when the dust is in very large quantities and lying within 15 feet of the shot.

An interesting paper has been communicated by Mr. M. Walton Brown, on Earth-shakes. Your Council, realizing the importance of this subject, have appointed a Committee to investigate it. They will be assisted by the recently elected honorary member, Dr. Garnett, Principal of the Durham College of Science. It is probable that it will also receive the attention of the Royal Commission now investigating the causes of accidents in mines.

The Committee appointed to investigate the causes of the explosion of the Air-receiver at Ryhope have been able to deduce from their experiments some indication of the cause of that occurrence, and in a short time their report will be made to the Institute.

The library, which has been completely re-organised, has been freely used by the members, 713 works having been taken out during the year. A catalogue of all the books, maps, and drawings it contains is going through the press.

Through the kindness of Mr. T. Hugh Bell, Chairman of the Middlesbrough Water Board, and Mr. Walter Scott, the contractor for the works which are being carried out at Hury Reservoir, near Barnard Castle, about 70 members of the Institute had a pleasant excursion to the works, and were very kindly received by the gentlemen in charge. A section across the valley on the line of the main puddle trench, together with a brief account of the works to be executed, will be found in the Transactions.

In conclusion, the Council consider that the members of the Institute have every reason to be satisfied with the work done during the past year.

Finance Report.

THE income for the year 1884-85 amounted to the sum of £1,849 2s. 1d., and the expenditure to £1,600 7s. 8d., leaving a surplus of income over expenditure of £248 14s. 5d.

The total amount of subscriptions and arrears received was £1,524 12s.

The arrears of unpaid subscriptions still remain at a large amount.

The Committee recommend that the sum of £500, part of the balance at the bank, be invested.

JOHN DAGLISH.
WM. COCHRANE.

ADVERTISEMENT.

THE Institute is not, as a body, responsible for the facts and opinions advanced in the Papers read, and in the Abstracts of the Conversations which occurred at the Meetings during the Session.

TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

Dr. *For the Year ending*

	£ s. d.	£ s. d.
To Balance at Bankers	785 11 8	
To Balance in hands of Treasurer	97 6 2	
		882 17 10
To Dividend at the rate of 8 per cent. per annum on 134 £20 Shares in the Institute and Coal Trade Chambers Company, Limited, for the half-year, December, 1884...	107 4 0	
To Ditto, 7 per cent., for the half-year, July, 1885	93 16 0	
	201 0 0	
To Interest on Investments with River Tyne Commissioners	48 13 4	
		249 13 4
To Rent of College Class-Rooms		49 5 9
To Subscriptions for 1884-5, from 411 Original Members ...	863 2 0	
To Do. do. 29 Ordinary Members ...	90 6 0	
To Do. do. 106 Associate Members ...	222 12 0	
To Do. do. 79 Students	82 19 0	
To Do. do. 1 New Ordinary Member	3 3 0	
To Do. do. 7 New Associate Members	14 14 0	
To Do. do. 6 New Students ...	6 6 0	
To Subscribing Collieries, &c., namely:—		
Ashington £2 2 0		
Birtley Iron Company 6 6 0		
Haswell 4 4 0		
Hetton 10 10 0		
Lambton 10 10 0		
Londonderry 10 10 0		
Marquess of Bute 10 10 0		
North Hetton 6 6 0		
Ryhope 4 4 0		
Seghill 2 2 0		
South Hetton and Murton 4 4 0		
Stella 2 2 0		
Throckley 2 2 0		
Victoria Garesfield 2 2 0		
Wearmouth 4 4 0		
	81 18 0	
	1,365 0 0	
To Members' Arrears 150 3 0		
To Students' do. 9 9 0		
	159 12 0	
		1,524 12 0
To Sale of Publications, per A. Reid	26 17 3	
Less 10 per cent. Commission	2 13 9	
	24 3 6	
To Sale of Publications, per Secretary	1 7 6	
		25 11 0
To Balance due Treasurer	... ...	19 8 1
		£2,751 8 0

INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

July 31st, 1885. Cr.

	£ s. d.	£ s. d.
By Paid A. Reid, Publishing Account	519 16 8	
By Do. Covers for Parts and Stitching	42 2 2	
By Do. Binding and Sewing Volumes	33 8 1	
By Do. Postage	48 16 0	
By Do. Stationery and Circulars	64 12 5	
By Do. Library	23 11 0	
		732 6 4
By Books for Library in addition to Amount paid A. Reid...	36 11 0	
By Printing and Stationery, ditto ditto ...	3 5 8	
By Abstracts of Foreign Papers	57 5 10	
By Secretary's Incidental Expenses and Postages	160 8 3	
By Sundry Accounts	61 7 3	
By Travelling Expenses	5 15 3	
By Secretary's Salary	300 0 0	
By Cashier's Do.	75 0 0	
By Reporter's Do.	12 12 0	
By Furniture	7 2 2	
By Rent	75 0 0	
By Rates and Taxes	30 4 7	
By Fire Insurance	9 0 5	
By Water, Gas, and Coals	34 8 11	
		868 1 4
		1,600 7 8
By Invested with River Tyne Commissioners		500 0 0
		2,100 7 8
By Balance at Bankers		651 0 4

Audited and found correct.

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
30th July, 1885.

£2,751 8 0

TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

DR. *For the Year ending*

	£	s.	d.	£	s.	d.
To Balance at Bankers	785	11	8			
To Balance in hands of Treasurer	97	6	2			
				882	17	10
To Dividend at the rate of 8 per cent. per annum on 134 £20 Shares in the Institute and Coal Trade Chambers Company, Limited, for the half-year, December, 1884...	107	4	0			
To Ditto, 7 per cent., for the half-year, July, 1885	93	16	0			
	201	0	0			
To Interest on Investments with River Tyne Commissioners	48	13	4			
				249	13	4
To Rent of College Class-Rooms				49	5	9
To Subscriptions for 1884-5, from 411 Original Members ...	863	2	0			
To Do. do. 29 Ordinary Members ...	90	6	0			
To Do. do. 106 Associate Members ...	222	12	0			
To Do. do. 79 Students	82	19	0			
To Do. do. 1 New Ordinary Member	3	3	0			
To Do. do. 7 New Associate Members	14	14	0			
To Do. do. 6 New Students ...	6	6	0			
To Subscribing Collieries, &c., namely:—						
Ashington	£2	2	0			
Birtley Iron Company	6	6	0			
Haswell	4	4	0			
Hetton	10	10	0			
Lambton	10	10	0			
Londonderry	10	10	0			
Marquess of Bute	10	10	0			
North Hetton	6	6	0			
Ryhope	4	4	0			
Seghill	2	2	0			
South Hetton and Murton	4	4	0			
Stella	2	2	0			
Throckley	2	2	0			
Victoria Garesfield	2	2	0			
Wearmouth	4	4	0			
				81	18	0
				1,365	0	0
To Members' Arrears	150	3	0			
To Students' do.	9	9	0			
				159	12	0
						1,524 12 0
To Sale of Publications, per A. Reid				26	17	3
Less 10 per cent. Commission				2	13	9
				24	3	6
To Sale of Publications, per Secretary				1	7	6
						25 11 0
To Balance due Treasurer						19 8 1
						£2,751 8 0

INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

July 31st, 1885. Cr.

	£	s.	d.	£	s.	d.
By Paid A. Reid, Publishing Account	519	16	8			
By Do. Covers for Parts and Stitching	42	2	2			
By Do. Binding and Sewing Volumes	33	8	1			
By Do. Postage	48	16	0			
By Do. Stationery and Circulars	64	12	5			
By Do. Library	23	11	0			
				732	6	4
By Books for Library in addition to Amount paid A. Reid...	36	11	0			
By Printing and Stationery, ditto ditto ...	3	5	8			
By Abstracts of Foreign Papers	57	5	10			
By Secretary's Incidental Expenses and Postages	160	8	3			
By Sundry Accounts	61	7	3			
By Travelling Expenses	5	15	3			
By Secretary's Salary	300	0	0			
By Cashier's Do.	75	0	0			
By Reporter's Do.	12	12	0			
By Furniture	7	2	2			
By Rent	75	0	0			
By Rates and Taxes	30	4	7			
By Fire Insurance	9	0	5			
By Water, Gas, and Coals	34	8	11			
				868	1	4
				1,600	7	8
By Invested with River Tyne Commissioners				500	0	0
				2,100	7	8
By Balance at Bankers				651	0	4
				£2,751	8	0

Audited and found correct.

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
30th July, 1885.

DR. THE TREASURER IN ACCOUNT

	£	s.	d.
To 511 Original Members, as per List 1884-85. 11 of whom are Life Members.			
500 @ £2 2s.	1,050	0	0
To 40 Ordinary Members, as per List 1884-85. 2 of whom are Life Members.			
38, 36 @ £3 3s., and 2 @ £2 2s.	117	12	0
To 132 Associate Members, as per List 1884-85. 6 of whom are Life Members.			
126 @ £2 2s.	264	12	0
To 106 Students, as per List 1884-85, @ £1 1s.	111	6	0
To 15 Subscribing Collieries	81	18	0
To 1 New Ordinary Member @ £3 3s.	3	3	0
To 7 New Associate Members @ £2 2s.	14	14	0
To 6 New Students @ £1 1s.	6	6	0
	1,649	11	0
To Arrears, as per Balance Sheet 1883-84 ... ... £468 6 0			
Deduct—Irrecoverable 49 7 0			
	418	19	0
	£2,068	10	0

Audited and found correct.

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
30th July, 1885.

WITH SUBSCRIPTIONS, 1884-85. CR.

		PAID. £ s. d.	UNPAID. £ s. d.
By 411 Original Members paid @ £2 2s.		863 2 0	.....
By 52 Do. unpaid		.....	109 4 0
By 9 Do. dead, unpaid		.....	18 18 0
By 9 Do. resigned, unpaid		.....	18 18 0
By 5 Do. gone, no address		.....	10 10 0
By 14 Do. struck off		.....	29 8 0
500			
By 28 Ordinary Members paid @ £3 3s.		88 4 0	.....
By 1 Do. paid @ £2 2s.		2 2 0	.....
By 7 Do. unpaid @ £3 3s.		.....	22 1 0
By 1 Do. unpaid @ £2 2s.		.....	2 2 0
By 1 Do. resigned		.....	3 3 0
38			
By 106 Associate Members paid @ £2 2s.		222 12 0	.....
By 13 Do. unpaid		.....	27 6 0
By 4 Do. resigned		.....	8 8 0
By 3 Do. struck off		.....	6 6 0
126			
By 79 Students paid @ £1 1s.		82 19 0	.....
By 21 Do. unpaid		.....	22 1 0
By 2 Do. gone, no address		.....	2 2 0
By 4 Do. struck off		.....	4 4 0
106			
By 15 Subscribing Collieries paid		81 18 0	.....
By 1 New Ordinary Member paid @ £3 3s.		3 3 0	.....
By 7 New Associate Members paid @ £2 2s.		14 14 0	.....
By 6 New Students paid @ £1 1s.		6 6 0	.....
		1,365 0 0	284 11 0
By Members' Arrears		150 3 0	235 4 0
By Students' Do.		9 9 0	24 3 0
		£1,524 12 0	543 18 0
			1,524 12 0
			£2,068 10 0

Dr. GENERAL STATEMENT, JULY 31st, 1885. Cr.

Liabilities.

	£	s.	d.
None	.....		
Capital	11,845	19	8

Audited and found correct.
(Share Certificates and Bond produced).

JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
30th July, 1885.

£11,845 19 8

Assets.

	£	s.	d
Balance of Account at Bankers £651 0 4			
Less due Treasurer 19 8 1			
	631	12	3
134 Shares of £20 each in the Institute and Coal Trade Chambers Company, Limited	2,680	0	0
Invested with the River Tyne Commissioners	1,500	0	0
Arrears of Subscriptions	543	18	0
Value of 360 Bound Volumes of Transactions, @ 11s. 6d. ...	207	0	0
Value of 5,209 Sewn Copies of Transactions, @ 9s.	2,344	1	0
Value of Sundry Sheets and Plates belonging to Vol. XXXIV., unfinished at date	275	4	11
Value of 35 Copies of Mr. T. F. Brown's Map of the South Wales Coal-field, @ 5s.	8	15	0
Value of 387 Copies of General Index, @ 3s.	58	1	0
Value of 763 Copies of Fossil Illustrations, @ 12s. 6d. ...	476	17	6
Value of 854 Copies of Fossil Catalogue, @ 5s.	213	10	0
Value of 835 Copies of Borings and Sinkings, Vol. I., @ 5s.	208	15	0
Value of 342 Copies of Borings and Sinkings, Vol. II., @ 5s.	85	10	0
Value of 373 Copies of Borings and Sinkings, Vol. III., @ 5s.	93	5	0
Value of 1,500 Vols. of Borings and Sinkings, in Sheets ...	300	0	0
Value of Sundry Sheets of Borings and Sinkings belonging to Vol. IV., unfinished at date	19	10	0
Value of Furniture and Office Fittings	450	0	0
Value of Books and Maps in Library...	1,750	0	0
	£11,845	19	8

Patrons.

His Grace the DUKE OF NORTHUMBERLAND.
His Grace the DUKE OF CLEVELAND.
The Most Noble the MARQUESS OF LONDONDERRY.
The Right Honourable the EARL OF LONSDALE.
The Right Honourable the EARL OF DURHAM.
The Right Honourable the EARL GREY.
The Right Honourable the EARL OF RAVENSWORTH.
The Right Honourable the EARL OF WHARNCLIFFE.
The Right Reverend the LORD BISHOP OF DURHAM.
The Very Reverend the DEAN AND CHAPTER OF DURHAM.
WENTWORTH B. BEAUMONT, Esq., M.P.

Honorary Members.

* Honorary Members during term of office only.

	Elected. Mem.	Hon.
The Right Honourable the EARL OF RAVENSWORTH, Ravensworth Castle, Gateshead-on-Tyne		1877
WILLIAM ALEXANDER, Esq., Inspector of Mines, Glasgow		1863
* Prof. P. PHILLIPS BEDSON, D. Sc. (Lond.), Durham College of Science, Newcastle-on-Tyne		1883
— DE BOUREUILLE, Esq., Commandeur de la Légion d'Honneur, Conseiller d'état, Inspecteur General des Mines, Paris		1853
* Prof. G. S. BRADY, M.D., F.R.S., F.L.S., Durham College of Science, Newcastle-on-Tyne		1875
Dr. BRASSERT, Berghauptmann, Bonn-am-Rhein, Prussia		1883
Dr. H. VON DECHEN, Berghauptmann, Bonn-am-Rhein, Prussia		1853
JOSEPH DICKINSON, Esq., Inspector of Mines, Manchester		1853
THOMAS EVANS, Esq., Inspector of Mines, Pen-y-Bryn, Duffield Road, Derby		1855
* WILLIAM GARNETT, Esq., M.A., Principal of the Durham College of Science, Newcastle-on-Tyne		1884
THEOPHILE GUIBAL, Esq., School of Mines, Mons, Belgium		1870
* HENRY HALL, Esq., Inspector of Mines, Rainhill, Prescott		1876
* Prof. A. S. HERSCHEL, M.A., F.R.S., F.R.A.S., Durham College of Science, Newcastle-on-Tyne		1872
The Very Rev. Dr. LAKE, Dean of Durham		1872
* Prof. G. A. LEBOUR, M.A., F.G.S., Durham College of Science, Newcastle-on-Tyne	1873	1879
* RALPH MOORE, Esq., Inspector of Mines, Glasgow		1866
WARINGTON W. SMYTH, Esq., 28, Jermyn Street, London		1869
E. VUILLEMIN, Esq., Mines d'Anîche, Nord, France		1878
* THOMAS E. WALES, Esq., Inspector of Mines, Swansea	1855	1866
* FRANK N. WARDELL, Esq., Inspector of Mines, Wath-on-Dearne, near Rotherham	1864	1868
* JAMES WILLIS, Esq., Inspector of Mines, 14, Portland Terrace, Newcastle-on-Tyne	1857	1871
THOMAS WYNNE, Esq., Inspector of Mines, Manor House, Gnosall, Stafford		1853

Life Members.

	Elected. Mem.	Life.
C. W. BARTHOLOMEW, Esq., Blakesley Hall, near Towcester	1875	1875
THOS. HUGH BELL, Esq., Middlesbro'-on-Tees	1882	1882
DAVID BURNS, Esq., C.E., Clydesdale Bank Buildings, Bank Street, Carlisle	1877	1877
T. E. CANDLER, Esq., Canton Club, Canton, China	1875	1885
E. B. COXE, Esq., Drifton, Jeddo, P.O., Luzerne Co., Penns., U.S.	1873	1874
JAMES S. DIXON, Esq., 170, Hope Street, Glasgow	1878	1880
ERNEST HAGUE, Esq., Castle Dyke, Sheffield	1872	1876
G. C. HEWITT, Esq., Coal Pit Heath Colliery, near Bristol	1871	1879
JAMES HILTON, Esq., Wigan Coal and Iron Co., Limited, Wigan	1867	1883
THOS. E. JOBLING, Esq., Croft Villa, Blyth, Northumberland	1876	1882
HENRY LAPORTE, Esq., M.E., 80, Rue Royale, Brussels	1877	1877
W. MERIVALE, c/o Mackinnon and Mackenzie, Bombay	1881	1884
NATHAN MILLER, Esq.	1878	1878
H. J. MORTON, Esq., 2, Westbourne Villas, South Cliff, Scarborough	1856	1861
RUDOLPH NASSE, Esq., Oberbergrath, Dortmund, Prussia	1869	1880
ARTHUR PEASE, Esq., M.P., Darlington	1882	1882
W. A. POTTER, Esq., Cramlington House, Northumberland	1853	1874
EDWARD G. PRIOR, Esq., Victoria, British Columbia	1880	1883
R. CLIFFORD SMITH, Esq., Parkfield, Swinton, Manchester	1874	1874
T. H. WARD, Esq., Assistant Manager, East Indian Railway Collieries, Giridi, Bengal, India	1882	1882

OFFICERS, 1885-86.

President.

JOHN DAGLISH, Esq., Marsden, South Shields.

Vice-Presidents.

WM. ARMSTRONG, Esq., Pelaw House, Chester-le-Street.
SIR LOWTHIAN BELL, Bart., Rounton Grange, Northallerton.
T. J. BEWICK, Esq., Haydon Bridge, Northumberland.
WM. COCHRANE, Esq., Grainger Street West, Newcastle-on-Tyne.
JOHN MARLEY, Esq., Thornfield, Darlington.
J. B. SIMPSON, Esq., Hedgefield House, Blaydon-on-Tyne.

Council.

WM. ARMSTRONG, Jun., Esq., Wingate, County Durham.
T. W. BENSON, Esq., 11, Newgate Street, Newcastle-on-Tyne.
C. BERKLEY, Esq., Marley Hill, Whickham, R.S.O., County Durham.
R. F. BOYD, Esq., Moor House, Leamside, Fence Houses.
S. C. CRONE, Esq., Killingworth Hall, Newcastle-on-Tyne.
RD. FORSTER, Esq., South Hetton, Fence Houses.
W. H. HEDLEY, Esq., Medomsley, Newcastle-on-Tyne.
THOS. HEPPELL, Esq., Leafield House, Chester-le-Street.
H. LAWRENCE, Esq., Grange Iron Works, Durham.
W. G. LAWS, Esq., Town Hall Buildings, Newcastle-on-Tyne.
PROF. G. A. LEBOUR, M.A., F.G.S., Durham College of Science, Newcastle.
W. LISHMAN, Esq., Bunker Hill, Fence Houses.
GEO. MAY, Esq., Harton Colliery Offices, near South Shields.
M. W. PARRINGTON, Esq., Wearmouth Colliery, Sunderland.
A. M. POTTER, Esq., Shire Moor Colliery, Earsdon, Newcastle.
R. ROBINSON, Esq., Howlish Hall, near Bishop Auckland.
J. G. WEEKS, Esq., Bedlington Collieries, Bedlington.
JAMES WILLIS, Esq., 14, Portland Terrace, Newcastle-on-Tyne.

Ex-officio

- SIR GEORGE ELLIOT, Bart., M.P., Houghton Hall, Fence Houses. — Past Presidents.
- E. F. BOYD, Esq., F.G.S., Moor House, Leamside, Fence Houses. — Past Presidents.
- SIR W. G. ARMSTRONG, C.B., LL.D., F.R.S., Jesmond, Newcastle-on-Tyne. — Past Presidents.
- LINDSAY WOOD, Esq., Southill, Chester-le-Street. — Past Presidents.
- G. C. GREENWELL, Esq., F.G.S., Elm Tree Lodge, Duffield, Derby. — Past Presidents.
- G. B. FORSTER, Esq., M.A., Lesbury, R.S.O., Northumberland. — Past Presidents.
- A. L. STEAVENSON, Esq., Durham. — Retiring Vice-President.

Secretary and Treasurer.

THEO. WOOD BUNNING, Neville Hall, Newcastle-on-Tyne.

List of Members.

AUGUST, 1885.

Original Members.

Marked * are Life Members.

		ELECTED
1	ADAMS, W., 15, Park Place, Cardiff	1854
2	ADAMSON, DANIEL, Engineering Works, Dukinfield, near Manchester	Aug. 7, 1875
3	AITKIN, HENRY, Falkirk, N.B.	Mar. 2, 1865
4	ALLISON, T., Belmont Mines, Guisbro'	Feb. 1, 1868
5	ANDERSON, C. W., Cleadon House, Harrogate	Aug. 21, 1852
6	ANDREWS, HUGH, Swarland Hall, Felton, Northumberland	Oct. 5, 1872
7	APPLEBY, C. E., Charing Cross Chambers, Duke St., Adelphi, London	Aug. 1, 1861
8	ARCHER, T., Dunston Engine Works, Gateshead	July 2, 1872
9	ARMSTRONG, SIR W. G., C.B., LL.D., F.R.S., Jesmond, Newcastle-upon-Tyne ... ... (PAST PRESIDENT, *Member of Council*)	May 3, 1866
10	ARMSTRONG, WM., Pelaw House, Chester-le-Street (VICE-PRESIDENT)	Aug. 21, 1852
11	ARMSTRONG, W., Jun., Wingate, Co. Durham (*Member of Council*)...	April 7, 1867
12	ARMSTRONG, W. L., Oaklands Rock, near Bewdley	Mar. 3, 1864
13	ARTHUR, D., M.E., Sherfin House, Baxenden, nr. Accrington, Manchester	Aug. 4, 1877
14	ASHWORTH, JAMES, Mapperley Colliery, West Hallam, Derby ...	Feb. 5, 1876
15	ASQUITH, T. W., Cowpen Colliery, Blyth, Northumberland	Feb. 2, 1867
16	ATKINSON, J. B., Stocksfield-on-Tyne	Mar. 5, 1870
17	ATKINSON, W. N., Shincliffe Hall, Durham	June 6, 1868
18	AUBREY, R. C., Wigan Coal & Iron Co. Ld., Standish, near Wigan ...	Feb. 5, 1870
19	AUSTINE, JOHN, Cadzow Coal Co., Glasgow	Nov. 4, 1876
20	AYNSLEY, WM., Brynkinalt Collieries, Chirk, Ruabon	Mar. 3, 1873
21	BAILES, GEORGE, Murton Colliery, Sunderland	Feb. 3, 1877
22	BAILES, T., 6, Collingwood Terrace, Jesmond Gardens, Newcastle ...	Oct. 7, 1858
23	BAILES, W., Cortonwood Collieries, Wombwell, near Barnsley ...	April 7, 1877
24	BAILEY, SAMUEL, Perry Barr, Birmingham	June 2, 1859
25	BAIN, R. DONALD, Newport, Monmouthshire	Mar. 3, 1873
26	BAINBRIDGE, E., Nunnery Colliery Offices, Sheffield	Dec. 3, 1863
27	BANKS, THOMAS, Leigh, near Manchester	Aug. 4, 1877
28	BARCLAY, A., Caledonia Foundry, Kilmarnock	Dec. 6, 1866
29	BARRAT, A. J.	Sept. 11, 1875
30	BARTHOLOMEW, C., Castle Hill House, Ealing, London, W.	Aug. 5, 1853
31	*BARTHOLOMEW, C. W., Blakesley Hall, near Towcester	Dec. 4, 1875
32	BASSETT, A., Tredegar Mineral Estate Office, Cardiff	1854
33	BATES, MATTHEW, Bews Hill, Blaydon-on-Tyne	Mar. 3, 1873
34	BATES, W. J., Winlaton, Blaydon-on-Tyne	Mar. 3, 1873
35	BATEY, JOHN, Newbury Collieries, Coleford, Bath	Dec. 5, 1868

ELECTED.

36 BEANLANDS, A., M.A., North Bailey, Durham ... ... Mar. 7, 1867
37 BELL, SIR LOWTHIAN, Bart., Rounton Grange, Northallerton, (VICE-PRESIDENT) ... ... July 6, 1854
38 BELL, JOHN, Messrs. Bell Brothers, Middlesbro'-on-Tees ... ... Oct. 1, 1857
39 BENSON, J. G., Accountant, 12, Grey Street, Newcastle-on-Tyne .. Nov. 7, 1874
40 BENSON, T. W., 11, Newgate Street, Newcastle *(Member of Council)* Aug. 2, 1866
41 BERKLEY, C., Marley Hill, Whickham R.S.O., Co. Durham (*Member of Council*) ... ... Aug. 21, 1852
42 BEWICK, T. J., M.I.C.E., F.G.S., Haydon Bridge, Northumberland (VICE-PRESIDENT) ... ... April 5, 1860
43 BIDDER, B. P., care of Mrs. Bidder, Park Road, Redhill, Surrey ... May 2, 1867
44 BIGLAND, J., Bedford Lodge, Bishop Auckland ... ... June 4, 1857
45 BINNS, C., Claycross, Derbyshire ... ... July 6, 1854
46 BIRAM, B., Peaseley Cross Collieries, St. Helen's, Lancashire ... 1856
47 BLACK, W., Hedworth Villa, South Shields ... ... April 2, 1870
48 BOLTON, H. H., Newchurch Collieries, near Manchester ... ... Dec. 5, 1868
49 BOOTH, R. L., Ashington Colliery, near Morpeth 1864
50 BOURNE, THOS. W., Minas Schwager, Coronel, Chili, South America... Sept. 11, 1875
51 BOYD, E. F., Moor House, Leamside, Fence Houses (PAST PRESIDENT, *Member of Council*) ... ... Aug. 21, 1852
52 BOYD, R. F., Moor House, Leamside, Fence Houses *(Mem. of Council)* Nov. 6, 1869
53 BOYD, WM., 74, Jesmond Road, Newcastle-on-Tyne ... ... Feb. 2, 1867
54 BRECKON, J. R., 32, Fawcett Street, Sunderland ... ... Sept. 3, 1864
55 BRETTELL, T., Mine Agent, Dudley, Worcestershire ... ... Nov. 3, 1866
56 BROMILOW, WM., 18, Leicester Street, Southport, Lancashire ... Sept. 2, 1876
57 BROWN, JOHN, Priory Place, 155, Bristol Road, Birmingham ... Oct. 5, 1854
58 BROWN, J. N., 56, Union Passage, New Street, Birmingham ... 1861
59 BROWN, THOS. FORSTER, Guildhall Chambers, Cardiff 1861
60 BROWNE, B. C., M.I.C.E., 2, Granville Road, Jesmond, Newcastle ... Oct. 1, 1870
61 BRYHAM, WILLIAM, Rosebridge Colliery, Wigan ... ... Aug. 1, 1861
62 BRYHAM, W., Jun., Douglas Bank Collieries, Wigan ... ... Aug. 3, 1865
63 BUNNING, THEO. WOOD, Neville Hall, Newcastle-on-Tyne *(Secretary and Treasurer)* 1864
64*BURNS, DAVID, C.E., Clydesdale Bank Buildings, Bank St., Carlisle... May 5, 1877
65 BURROWS, J. S., Yew Tree House, Atherton, near Manchester ... Oct. 11, 1873

66 CAMPBELL, W. B., Consulting Engineer, Grey Street, Newcastle ... Oct. 7, 1876
67 CARR, WM. COCHRAN, South Benwell, Newcastle-on-Tyne ... ... Dec. 3, 1857
68 CHAMBERS, A. M., Thorncliffe Iron Works, near Sheffield ... ... Mar. 6, 1869
69 CHEESMAN, I., Throckley Colliery, Newcastle-on-Tyne ... ... Feb. 1, 1873
70 CHEESMAN, W. T., Wire Rope Manufacturer, Hartlepool ... ... Feb. 5, 1876
71 CHILDE, ROWLAND, Wakefield, Yorkshire ... ... May 15, 1862
72 CLARENCE, THOMAS, Elswick Colliery, Newcastle-on-Tyne ... ... Dec. 4, 1875
73 CLARK, C. F., Garswood Coal and Iron Co., near Wigan ... ... Aug. 2, 1866
74 CLARK, R. B., Marley Hill, near Gateshead ... ... May 3, 1873
75 CLARK, W., M.E., The Grange, Teversall, near Mansfield ... ... April 7, 1866
76 CLARKE, WILLIAM, Victoria Engine Works, Gateshead ... ... Dec. 7, 1867

ELECTED.

77 COCHRANE, B., Aldin Grange, Durham ... ... Dec. 6, 1866
78 COCHRANE, C., The Grange, Stourbridge ... ... June 3, 1857
79 COCHRANE, W., St. John's Chambers, Grainger Street West, Newcastle (VICE-PRESIDENT) 1859
80 COLE, RICHARD, Walker Colliery, near Newcastle-on-Tyne ... . April 5, 1873
81 COLE, ROBERT HEATH, Lord Street, Basford, Stoke-upon-Trent ... Feb. 5, 1876
82 COLLIS, W. B., Swinford House, Stourbridge, Worcestershire ... June 6, 1861
83 COOK, J., Jun., Washington Iron Works, Gateshead ... ... May 8, 1869
84 COOKE, JOHN, Willington, R.S.O., Co. Durham ... ... Nov. 1, 1860
85 COOKSEY, JOSEPH, West Bromwich, Staffordshire ... ... Aug. 3, 1865
86 COOPER, R. E., C.E., 8, The Sanctuary, Westminster, London, S.W. ... Mar. 4, 1871
87 COOPER, T., Rosehill, Rotherham, Yorkshire ... ... April 2, 1863
88 CORBETT, V. W., Chilton Moor, Fence Houses ... ... Sept. 3, 1870
89 CORBITT, M., Wire Rope Manufacturer, Teams, Gateshead ... ... Dec. 4, 1875
90 COULSON, F., 10, Victoria Terrace, Durham ... ... Aug. 1, 1868
91 COULSON, W., 32, Crossgate, Durham ... ... Oct. 1, 1852
92 COWEN, JOS., M.P., Blaydon Burn, Newcastle-on-Tyne ... ... Oct. 5, 1854
93 COWEY, JOHN, Wearmouth Colliery, Sunderland ... ... Nov. 2, 1872
94 COX, JOHN H., 10, St. George's Square, Sunderland ... ... Feb. 6, 1875
95*COXE, E. B., Drifton, Jeddo, P. O. Luzerne Co., Penns., U.S. ... Feb. 1, 1873
96 COXON, S. B., 23, Great George Street, Westminster, London ... June 5, 1856
97 CRAIG, W. Y., Palace Chambers, St. Stephen's, Westminster, London Nov. 3, 1866
98 CRAWFORD, T., Littletown Colliery, near Durham ... ... Aug. 21, 1852
99 CRAWFORD, T., 3, Grasmere Street, Gateshead-on-Tyne ... ... Sept. 3, 1864
100 CRAWFORD, T., Jun. Littletown Colliery, near Durham ... ... Aug. 7, 1869
101 CRAWSHAY, E., Gateshead-on-Tyne ... ... Dec. 4, 1869
102 CRAWSHAY, G., Gateshead-on-Tyne ... ... Dec. 4, 1869
103 CRONE, E. W., Killingworth Hall, near Newcastle-on-Tyne ... ... Mar. 5, 1870
104 CRONE, J. R., Tudhoe House, *via* Spennymoor ... ... Feb. 1, 1868
105 CRONE, S. C., Killingworth Hall, Newcastle *(Member of Council)* ... 1853
106 CROSS, JOHN, 77, King Street, Manchester ... ... June 5, 1869
107 CROUDACE, C. J., Bettisfield Colliery Co., Limited, Bagillt, N. Wales Nov. 2, 1872
108 CROUDACE, JOHN, West House, Haltwhistle ... ... June 7, 1873
109 CROUDACE, THOMAS, Lambton Lodge, New South Wales 1862

110 DAGLISH, JOHN, Marsden, South Shields (PRESIDENT) ... ... Aug. 21, 1852
111 DAGLISH, W. S., Solicitor, Newcastle-on-Tyne ... ... July 2, 1872
112 DALE, DAVID, West Lodge, Darlington ... ... Feb. 5, 1870
113 D'ANDRIMONT, T., Liége, Belgium ... ... Sept. 3, 1870
114 DANIEL, W., Steam Plough Works, Leeds ... ... June 4, 1870
115 DARLING, FENWICK, South Durham Colliery, Darlington ... ... Nov. 6, 1875
116 DARLINGTON, JAMES, Black Park Colliery, Ruabon, North Wales ... Nov. 7, 1874
117 DARLINGTON, JOHN, 2, Coleman Street Buildings, Moorgate Street, Great Swan Alley, London ... ... April 1, 1865
118 DAVEY, HENRY, C.E., Leeds ... ... Oct. 11, 1873
119 DAY, W. H. ... ... Mar. 6, 1869
120 DEES, R. R., Solicitor, Newcastle-on-Tyne ... ... Oct. 7, 1871

ELECTED.

121 DIXON, D. W., Lumpsey Mines, Brotton, Saltburn-by-the-Sea ... Nov. 2, 1872
122 DIXON, NICH., Dudley Colliery, Dudley, Northumberland ... ... Sept. 1, 1877
123 DIXON, R., Wire Rope Manufacturer, Teams, Gateshead ... ... June 5, 1875
124 DODD, B., Bearpark Colliery, near Durham ... ... May 3, 1866
125 DODDS, JOSEPH, M.P., Stockton-on-Tees ... ... Mar. 7, 1874
126 DOUGLAS, C. P., Parliament Street, Consett, Co. Durham ... ... Mar. 6, 1869
127 DOUGLAS, T., Pease's' West Collieries, Darlington ... ... Aug. 21, 1852
128 DOVE, G., Viewfield, Stanwix, Carlisle ... ... July 2, 1872
129 DOWDESWELL, H., Butterknowle Colliery, *via* Darlington ... ... April 5, 1873
130 DYSON, GEORGE, Middlesborough ... ... June 2, 1866
131 DYSON, O., Pooley Hall Colliery, Polesworth, near Tamworth ... Mar. 2, 1872

132 EDDISON, ROBERT W., Steam Plough Works, Leeds ... ... Mar. 4, 1876
133 ELLIOT, SIR GEORGE, Bart., M.P., Houghton Hall, Fence Houses (PAST PRESIDENT, *Member of Council)* ... ... Aug. 21, 1852
134 ELSDON, ROBERT, 76, Manor Road, Upper New Cross, London ... Nov. 4, 1876
135 EMBLETON, T. W., The Cedars, Methley, Leeds ... ... Sept. 6, 1855
136 EMBLETON, T. W., Jun., The Cedars, Methley, Leeds ... ... Sept. 2, 1865
137 EMINSON, J. B., Londonderry Offices, Seaham Harbour ... ... Mar. 2, 1872
138 EVERARD, I. B., M.E., 6, Millstone Lane, Leicester ... ... Mar. 6, 1869

139 FARMER, A., Seaton Carew, near West Hartlepool ... ... Mar. 2, 1872
140 FARRAR, JAMES, Old Foundry, Barnsley ... ... July 2, 1872
141 FAVELL, THOMAS M., Etruria Iron Works, near Stoke-on-Trent ... April 5, 1873
142 FENWICK, BARNABAS, 84, Osborne Road, Newcastle-on-Tyne ... Aug. 2, 1866
143 FERENS, ROBINSON, Oswald Hall, near Durham ... ... April 7, 1877
144 FIDLER, E., Platt Lane Colliery, Wigan, Lancashire ... ... Sept. 1, 1866
145 FLETCHER, H., Ladyshore Coll., Little Lever, Bolton, Lancashire ... Aug. 3, 1865
146 FLETCHER, JAS., Manager Co-operative Collieries, Wallsend, near Newcastle, New South Wales ... ... Sept. 11, 1875
147 FLETCHER, JOHN, The Thorns, Lakeside, Newby Bridge, *via* Ulverston July 2, 1872
148 FOGGIN, WM., North Biddick Coll., Washington Station, Co. Durham Mar. 6, 1875
149 FORSTER, G. B., M.A., Lesbury, R.S.O., Northumberland (PAST PRESIDENT, *Member of Council*) ... ... Nov. 5, 1852
150 FORSTER, J. R., Water Company's Office, Newcastle-on-Tyne ... July 2, 1872
151 FORSTER, J. T., Burnhope Colliery, near Lanchester, Co. Durham ... Aug. 1, 1868
152 FORSTER, R., South Hetton, Fence Houses *(Member of Council)* ... Sept. 5, 1868
153 FOSTER, GEORGE, Osmondthorpe Colliery, near Leeds ... ... Mar. 7, 1874
154 FRANCE, FRANCIS, St. Helen's Colliery Co. Ld., St. Helen's, Lancashire Sept. 1, 1877
155 FRANCE, W., Lofthouse Mines, Loftus-in-Cleveland, R.S.O. ... ... April 6, 1867
156 FRANKS, GEO., Victoria Garesfield Colliery, Lintz Green, Newcastle ... Feb. 6, 1875
157 GALLOWAY, T. LINDSAY, M.A., Argyll Colliery, Campbeltown, N.B. Sept. 2, 1876
158 GERRARD, JOHN, Westgate, Wakefield ... ... Mar. 5, 1870
159 GILLETT, F. C., Midland Road, Derby ... ... July 4, 1861
160 GILPIN, EDWIN, 75, Birmingham Street, Halifax, Nova Scotia ... April 5, 1873
161 GILROY, G., Woodlands, Parbold, near Wigan ... ... Aug. 7, 1856
162 GILROY, S. B., Mining Engineer, Hednesford, Stafford ... ... Sept. 5, 1868

ELECTED.

163 GJERS, JOHN, Southfield Villas, Middlesbro' ... ... June 7, 1873
164 GODDARD, F. R., Accountant, Newcastle-on-Tyne ... ... Nov. 7, 1874
165 GORDON, JAMES N., c/o W. Nicolson, 5, Jeffrey's Square, St. Mary Axe, London, E.C. ... ... Nov. 6 1875
166 GRACE, E. N., Dhadka, Assensole, Bengal, India ... ... Feb. 1, 1868
167 GREAVES, J. O., St. John's, Wakefield ... ... Aug. 7, 1862
168 GREEN, J. T., Mining Engineer, Ty Celyn, Abercarn, Newport, Mon. Dec. 3, 1870
169 GREENER, JOHN, General Manager, Vale Coll., Pictou, Nova Scotia ... Feb. 6, 1875
170 GREENWELL, G. C., Elm Tree Lodge, Duffield, Derby (PAST PRESIDENT, *Member of Council)* ... ... Aug. 21, 1852
171 GREENWELL, G. C., Jun., Poynton, near Stockport ... ... Mar. 6, 1869
172 GREIG, D., Leeds ... ... Aug. 2, 1866
173 GREY, C. G., Land Commission, 24, Upper Merrion Street, Dublin ... May 4, 1872
174 GRIEVES, D., Brancepeth Colliery, Willington, County Durham ... Nov. 7, 1874
175 GRIFFITH, N. R., Wrexham 1866
176 GRIMSHAW, E. J., 23, Hardshaw Street, St. Helen's, Lancashire ... Sept. 5, 1868

177 HAGGIE, D. H., Wearmouth Patent Rope Works, Sunderland ... Mar. 4, 1876
178 HAGGIE, P., Gateshead 1854
179* HAGUE, ERNEST, Castle Dyke, Sheffield ... ... Mar. 2, 1872
180 HAINES, J. RICHARD, Adderley Green Colliery, near Longton ... Nov. 7, 1874
181 HALES, C., Nerquis Cottage, Nerquis, near Mold, Flintshire 1865
182 HALL, M., Lofthouse Station Collieries, near Wakefield ... ... Sept. 5, 1868
183 HALL, M. S., 10, Clarence Street, Bishop Auckland ... ... Feb. 14, 1874
184 HALL, WM., East Hetton Colliery Office, Coxhoe, Co. Durham ... Dec. 4, 1875
185 HALL, WILLIAM F., Haswell Colliery, Fence Houses ... ... May 13, 1858
186 HANN, EDMUND, Aberaman, Aberdare ... ... Sept. 5, 1868
187 HARBOTTLE, W. H., Orrell Colliery, near Wigan ... ... Dec. 4, 1875
188 HARDY, JOS. ... ... June 2, 1877
189 HARGREAVES, WILLIAM, Rothwell Haigh, Leeds ... ... Sept. 5, 1868
190 HARLE, RICHARD, Browney Colliery, Durham ... ... April 7, 1877
191 HARLE, WILLIAM, Pagebank Colliery, near Durham ... ... Oct. 7, 1876
192 HARRISON, R., Eastwood, near Nottingham 1861
193 HARRISON, T. E., C.E., Central Station, Newcastle-on-Tyne ... ... May 6, 1853
194 HARRISON, W. B., Brownhills Collieries, near Walsall ... ... April 6, 1867
195 HAY, J., Jun., Widdrington Colliery, Acklington ... ... Sept. 4, 1869
196 HECKELS, MATTHEW, F.G.S., Walker Colliery, Newcastle-on-Tyne ... April 11, 1874
197 HECKELS, W. J., Evenwood, Bishop Auckland ... ... May 2, 1868
198 HEDLEY, J. J., Consett Collieries, Leadgate, County Durham ... April 6, 1872
199 HEDLEY, J. L., Flooker's Brook, Chester ... ... Feb. 5, 1870
200 HEDLEY, T. F., Valuer, Sunderland ... ... Mar. 4, 1871
201 HEDLEY, W. H., Consett Collieries, Medomsley, Newcastle-on-Tyne *(Member of Council)* 1864
202 HENDERSON, H., Pelton Colliery, Chester-le-Street ... ... Feb. 14, 1874
203 HEPPELL, T., Leafield House, Birtley, Chester-le-Street *(Member of Council)* ... ... Aug. 6, 1863
204 HEPPELL, W., Western Hill, Durham ... ... Mar. 2, 1872

		ELECTED.
205	HERDMAN, J., Park Crescent, Bridgend, Glamorganshire	Oct. 4, 1860
206	HESLOP, C., Lingdale Mines, *via* Skelton, R.S.O., Yorks.	Feb. 1, 1868
207	HESLOP, GRAINGER, Whitwell Colliery, Sunderland	Oct. 5, 1872
208	HESLOP, J., Cavendish Hill, Sherwood, Nottingham	Feb. 6, 1864
209	HETHERINGTON, D., Coxlodge Colliery, Newcastle-on-Tyne	1859
210*	HEWITT, G. C., Coal Pit Heath Colliery, near Bristol	June 3, 1871
211	HEWLETT, A., Haseley Manor, Warwick	Mar. 7, 1861
212	HIGSON, JACOB, 94, Cross Street, Manchester	1861
213*	HILTON, J., Wigan Coal and Iron Co., Limited, Wigan	Dec. 7, 1867
214	HILTON, T. W., Wigan Coal and Iron Co., Limited, Wigan	Aug. 3, 1865
215	HINDMARSH, THOMAS, 12, Bomont Street, Cowpen Quay, Blyth ...	Sept. 2, 1876
216	HODGSON, J. W., 1, Falconar Street, Shieldfield, Newcastle	Feb. 5, 1870
217	HOLLIDAY, MARTIN F., Langley Grove, Durham	May 1, 1875
218	HOLMES, C., Grange Hill, near Bishop Auckland	April 11, 1874
219	HOMER, CHARLES J., Mining Engineer, Stoke-on-Trent	Aug. 3, 1865
220	HOOD, A., 6, Bute Crescent, Cardiff	April 18, 1861
221	HOPE, GEORGE, Success House, Fence Houses	Feb. 3, 1877
222	HORNSBY, H., Hamsteels Colliery, near Durham	Aug. 1, 1874
223	HORSLEY, W., Whitehill Point, Percy Main, Newcastle-on-Tyne ...	Mar. 5, 1857
224	HOSKOLD, H. D., C. and M.E., F.R.G.S., F.G.S., M. Soc. A., &c. ...	April 1, 1871
225	HOWARD, W. F., 13, Cavendish Street, Chesterfield	Aug. 1, 1861
226	HUDSON, JAMES, Albion Mines, Pictou, Nova Scotia	1862
227	HUMBLE, JOHN, West Pelton, Chester-le-Street	Mar. 4, 1871
228	HUMBLE, JOS., Staveley Works, near Chesterfield	June 2, 1866
229	HUNTER, J., 8, Hall Street, Dalton-in-Furness, Lancashire	Mar. 6, 1869
230	HUNTER, W., Monk Bretton Colliery, near Barnsley	Oct. 3, 1861
231	HUNTER, W. S., 34, Grey Street, Newcastle-on-Tyne	Feb. 1, 1868
232	HURST, T. G., F.G.S., Osborne Road, Newcastle-on-Tyne	Aug. 21, 1852
233	JACKSON, C. G., Chamber Colliery Co., Limited, Hollinwood	June 4, 1870
234	JACKSON, W. G., Loscoe Grange, Normanton, Yorkshire	June 7, 1873
235	JARRATT, J., Houghton Main Colliery, near Barnsley	Nov. 2, 1867
236	JEFFCOCK, T. W., 18, Bank Street, Sheffield	Sept. 4, 1869
237	JENKINS, W., M.E., Ocean S.C. Colls., Ystrad, nr. Pontypridd, So. Wales	Dec. 6, 1862
238	JENKINS, WM., Consett Iron Works, Consett, Durham	May 2, 1874
239	JOHNSON, JOHN, M.I.C.E., F.G.S., 21, Grainger St. W., Newcastle	Aug. 21, 1852
240	JOHNSON, J., Carlton Main Colliery, Barnsley	Mar. 7, 1874
241	JOHNSON, R. S., Sherburn Hall, Durham	Aug. 21, 1852
242	JOICEY, J. G., Forth Banks West Factory, Newcastle-on-Tyne ...	April 10, 1869
243	JOICEY, W. J., Urpeth Lodge, Chester-le-Street	Mar. 6, 1869
244	KENDALL, JOHN D., Roper Street, Whitehaven	Oct. 3, 1874
245	KIMPTON, J. G., 40, St. Mary's Gate, Derby	Oct. 5, 1872
246	KIRKBY, J. W., Ashgrove, Windygates, Fife	Feb. 1, 1873
247	KNOWLES, A., Swinton Old Hall, Manchester	Dec. 5, 1856
248	KNOWLES, JOHN, Westwood, Pendlebury, Manchester	Dec. 5, 1856

ELECTED.

249 LAMB, R., Bowthorn Colliery, Cleator Moor, near Whitehaven ... Sept. 2, 1865
250 LAMB, R. O., The Lawn, Ryton-on-Tyne ... ... Aug. 2, 1866
251 LAMB, RICHARD W., Coal Owner, Newcastle-on-Tyne... ... ... Nov. 2, 1872
252 LAMBERT, M. W., Widdrington Office, Quay, Newcastle-on-Tyne ... July 2, 1872
253 LANCASTER, JOHN, Bilton Grange, Rugby ... ... Mar. 2, 1865
254 LANDALE, A., Echo Bank, Inverkeithing, Fife ... ... Dec. 2, 1858
255*LAPORTE, HENRY, M.E., 80, Rue Royale, Brussels ... ... May 5, 1877
256 LAVERICK, ROBT., West Rainton, Fence Houses ... ... Sept. 2, 1876
257 LAWRENCE, HENRY, Grange Iron Works, Durham *(Mem. of Council)* Aug. 1, 1868
258 LAWS, H., Grainger Street W., Newcastle-on-Tyne ... ... Feb. 6, 1869
259 LEBOUR, G. A., M.A., F.G.S., Durham College of Science, Newcastle, *(Member of Council)* ... ... Feb. 1, 1873
260 LEE, GEORGE, Great Ayton, *vid* Northallerton ... ... June 4, 1870
261 LESLIE, ANDREW, Hebburn, Gateshead-on-Tyne ... ... Sept. 7, 1867
262 LEVER, ELLIS, Bowdon, Cheshire 1861
263 LEWIS, WILLIAM THOMAS, Mardy, Aberdare 1864
264 LIDDELL, G. H., Somerset House, Whitehaven ... ... Sept. 4, 1869
265 LINDOP, JAMES, Bloxwich, Walsall, Staffordshire ... ... Aug. 1, 1861
266 LINSLEY, R., Cramlington Colliery, Northumberland ... ... July 2, 1872
267 LINSLEY, S. W., Whitburn Colliery, South Shields ... ... Sept. 4, 1869
268 LISHMAN, T., Jun., Hetton Colliery, Fence Houses ... ... Nov. 5, 1870
269 LISHMAN, WM., Witton-le-Wear... 1857
270 LISHMAN, WM., Bunker Hill, Fence Houses *(Member of Council)* ... Mar. 7, 1861
271 LIVESEY, C., Bradford Colliery, near Manchester ... ... Aug. 3, 1865
272 LIVESEY, T., Bradford Colliery, near Manchester ... ... Nov. 7, 1874
273 LLEWELYN, L., Abersychan House, Abersychan ... ... May 4, 1872
274 LOGAN, WILLIAM, Langley Park Colliery, Durham ... ... Sept. 7, 1867
275 LONGBOTHAM, J., Barrow Collieries, Barnsley, Yorkshire ... ... May 2, 1868
276 LONGRIDGE, J. A., 15, Great George Street, Westminster, London, S.W. Aug. 21, 1852
277 LUPTON, A., F.G.S., 4, Albion Place, Leeds ... ... Nov. 6, 1869

278 MADDISON, HENRY, The Lindens, Darlington ... ... Nov. 6, 1875
279 MALING, C. T., Ford Pottery, Newcastle-on-Tyne ... ... Oct. 5, 1872
280 MAMMATT, J. E., C.E., St. Andrew's Chambers, Leeds 1864
281 MARLEY, JOHN, Thornfield, Darlington (VICE-PRESIDENT) ... ... Aug. 21, 1852
282 MARLEY, J. W., 7, Bondgate, Darlington ... ... Aug. 1, 1868
283 MARSHALL, F. C., Messrs, R. & W. Hawthorn, St. Peters, Newcastle. Aug. 2, 1866
284 MARSTON, W. B., Leeswood Vale Oil Works, Mold ... ... Oct. 3, 1868
285 MARTEN, E. B., C.E., Pedmore, near Stourbridge ... ... July 2, 1872
286 MATTHEWS, R. F., Ridley Hall, Bardon Mill, Carlisle ... ... Mar. 5, 1857
287 MAUGHAN, J. A., Nerbudda Coal & Iron Co. Ld., Garrawarra, C.P., India Nov. 7, 1863
288 MAY, GEO., Harton Colliery Offices, nr. So. Shields *(Mem. of Council)* Mar. 6, 1862
289 MCCREATH, J., 95, Bath Street, Glasgow ... ... Mar. 5, 1870
290 MCCULLOCH, DAVID, Beech Grove, Kilmarnock, N.B. ... ... Dec. 4, 1875
291 MCCULLOCH, H. J. ... ... Oct. 1, 1863
292 MCCULLOCH, W. ... ... Nov. 7, 1874
293 MCGHIE, T., Loch View, Burnside, Rutherglen, near Glasgow ... Oct. 1, 1857

		ELECTED.
294	McMURTRIE, J., Radstock Colliery, Bath	Nov. 7, 1863
295	MEIK, THOMAS, C.E., 6, York Place, Edinburgh	June 4, 1870
296	MERIVALE, J. H., 2, Victoria Villas, Newcastle-on-Tyne	May 5, 1877
297	MILLER, ROBERT, Beech Grove, Lock Park, Barnsley	Mar. 2, 1865
298	MILLS, M. H., Duckmanton Lodge, Chesterfield	Feb. 4, 1871
299	MITCHELL, CHAS., Jesmond, Newcastle-on-Tyne	April 11, 1874
300	MITCHELL, JOSEPH, Bolton Hall, Rotherham	Feb. 14, 1874
301	MITCHINSON, R., Jun., Pontop Coll., Lintz Green Station, Co. Durham	Feb. 4, 1865
302	MOFFAT, T., Montreal Iron Ore Works, Whitehaven	Sept. 4, 1869
303	MONKHOUSE, JOS., Gilcrux, Cockermouth	June 4, 1863
304	MOOR, T., Cambois Colliery, Blyth	Oct. 3, 1868
305	MOOR, WM., Jun., Hetton Colliery, Fence Houses	July 2, 1872
306	MOORE, R. W., Colliery Office, Whitehaven	Nov. 5, 1870
307	MORRIS, W., Waldridge Colliery, Chester-le-Street	1858
308*	MORTON, H. J., 2, Westbourne Villas, South Cliff, Scarborough	Dec. 5, 1856
309	MORTON, H. T., Lambton, Fence Houses	Aug. 21, 1852
310	MOSES, WM., Wardley Colliery, Newcastle-on-Tyne	Mar. 2, 1872
311	MULVANY, W. T., Pempelfort, Dusseldorf-on-the-Rhine	Dec. 3, 1857
312	MUNDLE, ARTHUR, St. Nicholas Chambers, Newcastle-on-Tyne	June 5, 1875
313	MUNDLE, W., Redesdale Mines, Bellingham	Aug. 2, 1873
314*	NASSE, RUDOLPH, Oberbergrath, Dortmund, Prussia	1869
315	NEVIN, JOHN, Dunbottle House, Mirfield, Normanton	May 2, 1868
316	NEWALL, R. S., Ferndene, Gateshead-on-Tyne	May 2, 1863
317	NICHOLSON, E., jun., Beamish Colliery, Chester-le-Street	Aug. 7, 1869
318	NICHOLSON, MARSHALL, Middleton Hall, Leeds	Nov. 7, 1863
319	NOBLE, CAPTAIN, Jesmond, Newcastle-on-Tyne	Feb. 3, 1866
320	NORTH, F. W., F.G.S., Rowley Hall Colliery, Dudley, Staffordshire	Oct. 6, 1864
321	OGDEN, JOHN M., Solicitor, Sunniside, Sunderland	Mar. 5, 1857
322	OGILVIE, A. GRAEME, 4, Great George Street, Westminster, London	Mar. 3, 1877
323	OLIVER, ROBERT, Charlaw Colliery, near Durham	Nov. 6, 1875
324	PALMER, A. S., Usworth Hall, Washington Station, Co. Durham	July 2, 1872
325	PALMER, C. M., M.P., Quay, Newcastle-on-Tyne	Nov. 5, 1852
326	PAMELY, C., Springfield, Berw Road, Pontypridd, South Wales	Sept. 5, 1868
327	PANTON, F. S., Silksworth Colliery, Sunderland	Oct. 5, 1867
328	PARKIN, C., Hamsteels Colliery, near Durham	June 5, 1875
329	PARRINGTON, M. W., Wearmouth Coll., Sunderland *(Mem. of Council)*	Dec. 1, 1864
330	PARTON, T., F.G.S., Hill Top, West Bromwich	Oct. 2, 1869
331	PEACE, M. W., Wigan, Lancashire	July 2, 1872
332	PEACOCK, DAVID, West Bromwich	Aug. 7, 1869
333	PEARCE, F. H., Bowling Iron Works, Bradford	Oct. 1, 1857
334	PEASE, Sir J. W., Bart., M.P., Hutton Hall, Guisbro', Yorkshire	Mar. 5, 1857
335	PEEL, JOHN, Wharncliffe Silkstone Collieries, near Barnsley	Nov. 1, 1860
336	PEEL, JOHN, Leasingthorne Colliery, Bishop Auckland	Mar. 3, 1877
337	PEILE, WILLIAM, Ellerkeld, Stainburn, Workington	Oct. 1, 1863

ELECTED.

338 PENMAN, J. H., 2, Clarence Buildings, Booth Street, Manchester ... Mar. 7, 1874
339 PICKUP, P. W., Rishton, near Blackburn ... ... Feb. 6, 1875
340 PINCHING, ARCHD. E., The Terrace, Gravesend, Kent... ... ... May 5, 1877
341 POTTER, ADDISON, C.B., Heaton Hall, Newcastle-on-Tyne ... ... Mar. 6, 1869
342 POTTER, A. M., Shire Moor Coll., Earsdon, Newcastle *(Mem. of Council)* Feb. 3, 1872
343 POTTER, C. J., Heaton Hall, Newcastle-on-Tyne ... ... Oct. 3, 1874
344* POTTER, W. A., Cramlington House, Northumberland 1853
345 PRICE, JOHN, Rose Villa, Jarrow-on-Tyne ... ... Mar. 3, 1877
346 PRICE, J. R., Standish, near Wigan ... ... Aug. 7, 1869
347 PRIESTMAN, JONATHAN, Coal Owner, Newcastle-on-Tyne ... ... Sept. 2, 1871
348 PRINGLE, EDWARD, Choppington Colliery, Northumberland ... ... Aug. 4, 1877

349 RAMSAY, J. A., Thornley House, by Trimdon Grange, Co. Durham ... Mar. 6, 1869
350 RAMSAY, WM., Tursdale Colliery, County Durham ... ... Sept. 11, 1875
351 REED, ROBERT, Felling Colliery, Gateshead ... ... Dec. 3, 1863
352 REES, DANIEL, Glandare, Aberdare 1862
353 REID, ANDREW, Newcastle-on-Tyne ... ... April 2, 1870
354 RICHARDSON, H., Backworth Colliery, Newcastle-on-Tyne ... ... Mar. 2, 1865
355 RICHARDSON, J. W., Iron Shipbuilder, Newcastle-on-Tyne ... ... Sept. 3, 1870
356 RIDLEY, G., Tyne Chambers, 38, Side, Newcastle-on-Tyne ... ... Feb. 4, 1865
357 RIDLEY, J. H., Messrs. R. & W. Hawthorn, Newcastle-on-Tyne ... April 6, 1872
358 RIDYARD, J., Bridgewater Offices, Walkden, nr. Bolton-le-Moors, Lan. Nov. 7, 1874
359 RITSON, U. A., 6, Queen Street, Newcastle-on-Tyne ... ... Oct. 7, 1871
360 RITSON, W. A., Tamworth Colliery Co., Tamworth ... ... April 2, 1870
361 ROBERTSON, W., M.E., 123, St. Vincent Street, Glasgow ... ... Mar. 5, 1870
362 ROBINSON, G. C., Brereton and Hayes Colls., Rugeley, Staffordshire... Nov. 5, 1870
363 ROBINSON, R., Howlish Hall, near Bishop Auckland *(Mem. of Council)* Feb. 1, 1868
364 ROBSON, J. S., Butterknowle Colliery, *via* Darlington... 1853
365 ROBSON, THOMAS, Lumley Colliery, Fence Houses ... ... Oct. 4, 1860
366 ROGERSON, John, Croxdale Hall, Durham ... ... Mar. 6, 1869
367 ROSCAMP, J., Shilbottle Colliery, Lesbury, R.S.O., Northumberland... Feb. 2, 1867
368 ROSS, J. A. G., Consulting Engineer, 13, Belgrave Terrace, Newcastle July 2, 1872
369 ROSSER, W., Mineral Surveyor, Llanelly, Carmarthenshire 1856
370 ROTHWELL, R. P., 27, Park Place, New York, U.S. ... ... Mar. 5, 1870
371 ROUTLEDGE, Jos., Ryhope Colliery, Sunderland ... ... Sept. 11, 1875
372 ROUTLEDGE, WM., S. and L.C. and R. Co., Reserve Colliery, Sydney, Cape Breton ... ... Aug. 6, 1857
373 RUTHERFORD, J., Halifax Coal Co., Ld., Albion Mines, Nova Scotia... 1852
374 RUTHERFORD, W., So. Derwent Colliery, Annfield Plain, Lintz Green Oct. 3, 1874
375 RUTTER, THOS., 18, Victoria Street, Dunston, Gateshead ... ... May 1, 1875
376 RYDER, W. J. H., Forth Street Brass Works, Newcastle-on-Tyne ... Nov. 4, 1876

377 SAINT, GEORGE, Vauxhall Collieries, Ruabon, North Wales ... ... April 11, 1874
378 SCARTH, W. T., Raby Castle, Staindrop, Darlington ... ... April 4, 1868
379 SCOTT, ANDREW, Broomhill Colliery, Acklington ... ... Dec. 7, 1867
380 SCOTT, C. F., Medomsley, Lintz Green, Newcastle-on-Tyne ... ... April 11, 1874

ELECTED.

381 SCOULAR, G., Cleator Moor, *via* Carnforth ... ... July 2, 1872
382 SHAW, W., Wolsingham, *via* Darlington ... ... June 3, 1871
383 SHIEL, JOHN, Framwellgate Colliery, County Durham ... ... May 6, 1871
384 SHONE, ISAAC, 4, Westminster Chambers, Victoria Street, London, S.W. 1858
385 SHORTREDE, T., Park House, Winstanley, Wigan ... ... April 3, 1856
386 SHUTE, C. A., Westoe, South Shields ... ... April 11, 1874
387 SIMPSON, J., Heworth Colliery, near Gateshead-on-Tyne ... ... Dec. 6, 1866
388 SIMPSON, J. B., Hedgefield House, Blaydon-on-Tyne (VICE-PRESIDENT) Oct. 4, 1860
389 SIMPSON, R., Moor House, Ryton-on-Tyne ... ... Aug. 21, 1852
390 SIMPSON, ROBT., Drummond Coll., Westville, Pictou, Nova Scotia ... Dec. 4, 1875
391 SLINN, T., 2, Choppington Street, Westmorland Road, Newcastle ... July 2, 1872
392 SMITH, G. F., Grovehurst, Tunbridge Wells ... ... Aug. 5, 1853
393*SMITH, R. CLIFFORD, Parkfield, Swinton, Manchester ... ... Dec. 5, 1874
394 SMITH, T., Sen., M.E., Cinderford Villas, nr. Newnham, Gloucester... May 5, 1877
395 SMITH, T. E., Phœnix Foundry, Newgate Street, Newcastle-on-Tyne Dec. 5, 1874
396 SNOWDON, T., jun., Helmepark, near Tow Law, *via* Darlington ... Sept. 4, 1869
397 SOPWITH, A., Cannock Chase Collieries, near Walsall ... ... Aug. 1, 1868
398 SOPWITH, THOS., 6, Great George St., Westminster, London, S.W. ... Mar. 3, 1877
399 SOUTHERN, R., Burleigh House, The Parade, Tredegarville, Cardiff ... Aug. 3, 1865
400 SOUTHWORTH, THOS., Hindley Green Collieries, near Wigan ... ... May 2, 1874
401 SPENCER, JOHN, Westgate Road, Newcastle-on-Tyne ... ... Sept. 4, 1869
402 SPENCER, M., Newburn, near Newcastle-on-Tyne ... ... Sept. 4, 1869
403 SPENCER, T., Ryton, Newcastle-on-Tyne ... ... Dec. 6, 1866
404 SPENCER, W., Southfields, Leicester ... ... Aug. 21, 1852
405 STEAVENSON, A. L., Durham (RETIRING VICE-PRES., *Mem. of Council)* Dec. 6, 1855
406 STEPHENSON, G. R., 9, Victoria Chambers, Westminster, London, S.W. Oct. 4, 1860
407 STEVENSON, R., Janefield Place, Lylesland, Paisley, N.B. ... ... Feb. 5, 1876
408 STOBART, W., Pepper Arden, Northallerton ... ... July 2, 1872
409 STOREY, THOS. E., Clough Hall Iron Works, Kidsgrove, Staffordshire Feb. 5, 1876
410 STRAKER, J. H., Stagshaw House, Corbridge-on-Tyne ... ... Oct. 3, 1874
411 STRATTON, T. H. M., Tredegar, South Wales ... ... Dec. 3, 1870
412 SWALLOW, J., Bushblades House, Lintz Green, Newcastle-on-Tyne ... May 2, 1874
413 SWALLOW, R. T., Springwell, Gateshead-on-Tyne 1862
414 SWAN, H. F., Shipbuilder, Newcastle-on-Tyne ... ... Sept. 2, 1871
415 SWAN, J. G., Upsall Hall, near Middlesbro' ... ... Sept. 2, 1871
416 SWANN, C. G., Sec., General Mining Asso. Ld., 6, New Broad St., London Aug. 7, 1875

417 TATE, SIMON, Trimdon Grange Colliery, Co. Durham ... ... Sept. 11, 1875
418 TAYLOR, HUGH, King Street, Quay, Newcastle-on-Tyne ... ... Sept. 5, 1856
419 TAYLOR, T., King Street, Quay, Newcastle-on-Tyne ... ... July 2, 1872
420 TAYLOR-SMITH, THOMAS, Greencroft Park, Durham ... ... Aug. 2, 1866
421 THOMPSON, R., Jun., Rodridge House, Wingate, Co. Durham ... Sept. 7, 1867
422 THOMPSON, T. C., Milton Hall, Carlisle ... ... May 4, 1854
423 THOMSON, JOHN, Eston Mines, by Middlesbro' ... ... April 7, 1877
424 THOMSON, JOS. F., Manvers Main Colliery, Rotherham ... ... Feb. 6, 1875
425 TINN, J., C.E., Ashton Iron Rolling Mills, Bedminster, Bristol ... Sept. 7, 1867
426 TYLDEN-WRIGHT, C., Shireoaks Colliery, Worksop, Notts. 1862

ELECTED.

427 Tyson, Wm. John, 15, Foxhouses Road, Whitehaven ... ... Mar. 3, 1877
428 Tyzack, D., c/o Mr. Donnison, 71, Westgate Road, Newcastle-on-Tyne Feb. 14, 1874
429 Tyzack, Wilfred, So. Medomsley Coll., Lintz Green, Newcastle ... Oct. 7, 1876

430 Vivian, John, Diamond Boring Company, Whitehaven ... ... Mar. 3, 1877

431 Wadham, E., C. and M.E., Millwood, Dalton-in-Furness ... ... Dec. 7, 1867
432 Walker, J. S., Pagefield Ironworks, Wigan, Lancashire ... ... Dec. 4, 1869
433 Walker, W., Saltburn-by-the-Sea ... ... Mar. 5, 1870
434 Wallace, Henry, Trench Hall, Gateshead ... ... Nov. 2, 1872
435 Ward, H., Rodbaston Hall, near Penkridge, Stafford... ... ... Mar. 6, 1862
436 Wardale, John D., Redheugh Engine Works, Gateshead ... ... May 1, 1875
437 Wardell, S. C., Doe Hill House, Alfreton ... ... April 1, 1865
438 Watson, H., High Bridge Works, Newcastle-on-Tyne ... ... Mar. 7, 1868
439 Watson, H. B., High Bridge Works, Newcastle-on-Tyne ... ... Mar. 3, 1877
440 Watson, M., Curzon Street, Maryport ... ... Mar. 7, 1868
441 Weeks, J. G., Bedlington Collieries, Bedlington *(Member of Council)* Feb. 4, 1865
442 Westmacott, P. G. B., Elswick Iron Works, Newcastle ... ... June 2, 1866
443 White, H., Weardale Coal Company, Tow Law, near Darlington ... 1866
444 White, J. F., M.E., Wakefield ... ... July 2, 1872
445 White, J. W. H., Woodlesford, near Leeds ... ... Sept. 2, 1876
446 Whitehead, James, Brindle Lodge, near Preston, Lancashire ... Dec. 4, 1875
447 Whitelaw, John, 118, George Street, Edinburgh ... ... Feb. 5, 1870
448 Whitelaw, T., 112, Wellington Street, Glasgow ... ... April 6, 1872
449 Whittem, Thos. S., Wyken Colliery, near Coventry ... ... Dec. 5, 1874
450 Widdas, C., North Bitchburn Colliery, Howden, Darlington... ... Dec. 5, 1868
451 Wight, W. H., Cowpen Colliery, Blyth... ... ... Feb. 3, 1877
452 Wild, J. G., Hedley Hope Collieries, Tow Law, by Darlington ... Oct. 5, 1867
453 Williams, E., Cleveland Lodge, Middlesbro' ... ... Sept. 2, 1865
454 Williamson, John, Cannock, &c., Collieries, Hednesford ... ... Nov. 2, 1872
455 Willis, J., 14, Portland Terrace, Newcastle *(Member of Council)* ... Mar. 5, 1857
456 Wilson, J. B., Wingfield Iron Works and Colliery, Alfreton... ... Nov. 5, 1852
457 Wilson, Robert, Flimby Colliery, Maryport ... ... Aug. 1, 1874
458 Wilson, W. B., Kippax Colliery, near Leeds ... ... Feb. 6, 1869
459 Winter, T. B., Grey Street, Newcastle-on-Tyne ... ... Oct. 7, 1871
460 Wood, C. L., Freeland, Forgandenny, Perthshire 1853
461 Wood, Lindsay, Southill, Chester-le-Street (Past President, *Member of Council)* ... ... Oct. 1, 1857
462 Wood, Thomas, Rainton House, Fence Houses ... ... Sept. 3, 1870
463 Wood, W. H., Coxhoe Hall, Coxhoe, Co. Durham 1856
464 Wood, W. O., Durham ... ... Nov. 7, 1863
465 Woolcock, Henry, St. Bees, Cumberland ... ... Mar. 3, 1873
466 Wright, Rev. G. H., Church of England Temperance Society, Westminster Bridge, London, W.... ... ... July 2, 1872
467 Wrightson, T., Stockton-on-Tees ... ... Sept. 13, 1873

468 Young, Philip ... ... Oct. 11, 1873

Ordinary Members.

Marked * are Life Members.

		ELECTED.
1	ACKROYD, WM., Jun., Morley Main Collieries, Morley, nr. Leeds ...	Feb. 7, 1880
2	BELL, C. E., Park House, Durham	Dec. 3, 1870
3	BROJA, RICHARD, Oberbergrath, Ostwall, Dortmund...	Nov. 6, 1880
4	CHARLTON, HENRY, Hawks, Crawshay, & Sons, Gateshead-on-Tyne	Dec. 9, 1882
5	COCHRANE, JOHN E.	Dec. 9, 1882
6	CROSS, W. A., Messrs. R. and W. Hawthorn, Newcastle-on-Tyne ...	April 12, 1884
7	DACRES, THOMAS, Dearham Colliery, *via* Carlisle	May 4, 1878
8	DEES, J. G., Floraville, Whitehaven	Oct. 13, 1883
9*	DIXON, JAMES S., 170, Hope Street, Glasgow	Aug. 3, 1878
10	ELLIS, W. R., F.G.S., Wigan	June 1, 1878
11	FORREST, B. J., care of J. C. Forrest, Witley Coal Co., Ld., Halesowen, Birmingham	April 12, 1884
12	FORREST, J. C., Witley Coal Co., Limited, Halesowen, Birmingham...	April 12, 1884
13	GEDDES, GEORGE H., 142 Princes Street, Edinburgh	Oct. 1, 1881
14	GILCHRIST, THOMAS, Eltringham, Prudhoe-on-Tyne	May 4, 1878
15	GOUDIE, J. H., 13, Lowther Street, Whitehaven	Sept. 7, 1878
16	HARBOTTLE, JOHN, Hudson, Columbia Co., New York, U.S.A. ...	June 10, 1882
17	JAMESON, JOHN, Akenside Hill, Newcastle-on-Tyne	April 12, 1884
18	JOHNSON, H., Jun., Sandwell Park Colliery, West Bromwich, So. Staff.	Feb. 10, 1883
19	JOHNSON, WILLIAM, West Stanley Colliery, R.S.O., Co. Durham ...	Dec. 9, 1882
20	KELLETT, WILLIAM, Wigan	June 1, 1878
21	KNOWLES, I., Wigan	Oct. 13, 1883
22	LANCASTER, JOHN, Auchinbeath, Southfield and Fence Collieries, Lesmahagow	Sept. 7, 1878
23	LAWS, W. G., Town Hall, Newcastle-on-Tyne *(Member of Council)*...	Oct. 2, 1880
24	LEACH, C. C., 18, Lord Street, Liverpool	Mar. 7, 1874
25	LIDDELL, MATTHEW, Mickley Colliery Offices, Stocksfield-on-Tyne ...	Feb. 10, 1883
26	LLEWELLIN, DAVID MORGAN, F.G.S., Glanwern Offices, Pontypool ...	May 14, 1881
27	MARTIN, TOM PATTINSON, Allhallows Colliery, Mealsgate, Carlisle ...	Feb. 15, 1879
28	OLDHAM, G. H., Barrett Berhm, De Haap Goldfields, Transvaal, South Africa	Aug. 5, 1882
29	POTTS, JOS., Jun., North Cliff, Roker, Sunderland	Dec. 6, 1879
30*	PRIOR, EDWARD G., Victoria, British Columbia...	Feb. 7, 1880
31	RHODES, C. E., Carr House, Rotherham	Aug. 4, 1883
32	ROGERS, WILLIAM, 30, King Street, Wigan	Nov. 2, 1878
33	RUSSELL, ROBERT, Coltness Iron Works, Newmains, N.B.	Aug. 3, 1878
34	SELBY, ATHERTON, Leigh, near Manchester	Oct. 13, 1883
35	SPENCER, JOHN W., Newburn, near Newcastle-on-Tyne	May 4, 1878
36	STEVENS, JAMES, M.E., Kaiping Mines, c/o H.B.M's. Consulate, Tientsin, North China	Feb. 14, 1885
37	TOPPING, WALTER, Messrs. Cross, Tetley, & Co., Bamfurlong, nr. Wigan	Mar. 2, 1878
38	WALKER, SYDNEY FERRIS, 195, Severn Road, Canton, Cardiff ...	Dec. 9, 1882
39	WALKER, WILLIAM EDWARD, Lowther Street, Whitehaven	Nov. 19, 1881
40	WINSTANLEY, ROBT., M.E., 28, Deansgate, Manchester	Sept. 7, 1878

Associate Members.

Marked * are Life Members.

		ELECTED.
1	ALLAN, JOHN	Feb. 10, 1883
2	ARMSTRONG, HENRY, Pelaw House, Chester-le-Street	April 14, 1883
3	ARMSTRONG, J. H., St. Nicholas Chambers, Newcastle-on-Tyne ...	Aug. 1, 1885
4	ARMSTRONG, T. J., Hawthorn Terrace, Newcastle-on-Tyne	Feb. 10, 1883
5	ARNOLD, THOS., Mineral Surveyor, Castle Hill, Greenfields, Llanelly	Oct. 2, 1880
6	ATKINSON, FRED., Maryport	Feb. 14, 1874
7	AUDUS, T., Mineral Traffic Manager, N.E. Railway, Newcastle-on-Tyne	Aug. 7, 1880
8	AYTON, E. F., El Boté Mining Negociation, Zacatecas, Mexico ...	Feb. 5, 1876
9	AYTON, HENRY, Seaton Delaval Colliery, Dudley, Northumberland ...	Mar. 6, 1875
10	BAILES, E. T., Wingate, Ferryhill	June 7, 1879
11	BARNES, A. W., Grassmore Colliery, near Chesterfield	Oct. 5, 1872
12	BARRETT, C. R., New Seaham, Sunderland	Nov. 7, 1874
13	BATES, C. J., Heddon Banks, near Wylam-on-Tyne	Dec. 11, 1882
14*	BELL, THOMAS HUGH, Middlesbrough-on-Tees	Dec. 11, 1882
15	BERKLEY, FREDERICK, Murton Colliery, near Sunderland	Dec. 11, 1882
16	BERKLEY, R. W., Marley Hill, Whickham, R.S.O., Co. Durham ...	Feb. 14, 1874
17	BEWICK, T. B., Haydon Bridge, Northumberland	Mar. 7, 1874
18	BIRD, W. J., Wingate, County Durham	Nov. 6, 1875
19	BLACKETT, W. C., Jun., Kimblesworth Colliery, Chester-le-Street ...	Nov. 4, 1876
20	BOUCHER, A. S., La Salada puerto Bertio, E de Antioquia, United States of Colombia, S.A.	Aug. 4, 1883
21	BOWES, JOHN, Streatlam Castle, Darlington	Feb. 10, 1883
22	BROUGH, THOMAS, Seaham Colliery, Sunderland	Feb. 1, 1873
23	BROWN, C. GILPIN, Hetton Colliery, Fence Houses	Nov. 4, 1876
24	BROWN, M. Walton, 3, Summerhill Terrace, Newcastle-on-Tyne ...	Oct. 7, 1871
25	BROWN, W. B., 101, Leadenhall Street, London, E.C.	Mar. 2, 1878
26	BRUCE, JOHN, Cannock Chase Colliery, near Walsall	Feb. 14, 1874
27	BULMAN, H. F., West Rainton, Fence Houses	May 2, 1874
28	BUNNING, C. Z., Warora Colliery, Central Provinces, India	Dec. 6, 1873
29	BURDON, A. E., Hartford House, Cramlington, Northumberland ...	Feb. 10, 1883
30	CABRERA, FIDEL, c/o H. Kendall & Son, 53, Old Broad Street, London	Oct. 6, 1877
31*	CANDLER, T. E., Canton Club, Canton, China	May 1, 1875
32	CHARLTON, W. A., Tangye Bros., 25, Lincoln St., Gateshead-on-Tyne	Nov. 6, 1880
33	CLOUGH, JAMES, Bedlington Collieries, R.S.O., Northumberland ...	April 5, 1873
34	COCHRANE, RALPH D., Hetton Colliery Offices, Fence Houses ...	June 1, 1878
35	COCKSON, CHARLES, Ince Coal and Cannel Co., Ince, Wigan	April 22, 1882
36	COOPER, R. W., Solicitor, Newcastle-on-Tyne	Sept. 4, 1880
37	CRAWFORD, T. W., Bishop Auckland	Dec. 4, 1875
38	DAKERS, W. R., Croxdale Colliery, Durham	Oct. 14, 1882
39	DAVIDSON, C. C., Main Street, St. Bees, Cumberland	Nov. 4, 1876

		ELECTED
40	DAVISON, CHARLES, Cornsay Colliery, near Esh, Durham	Dec. 11, 1882
41	DODD, M., Lemington, Scotswood-on-Tyne	Dec. 4, 1875
42	DONKIN, WM., Mohpani Mines, Gadawara, C.P., India	Sept. 2, 1876
43	DOUGLAS, JOHN, Seghill Colliery, Dudley, Northumberland	April 22, 1882
44	DOUGLAS, JOHN, Jun., Seghill Colliery, Dudley, Northumberland ...	April 22, 1882
45	DOUGLAS, M. H., Marsden Colliery, South Shields	Aug. 2, 1879
46	DOYLE, PATRICK, C.E., F.M.S., F.L.S., M.R.A.S., F.G.S., M.S.I., c/o Rev. James Doyle, R.C. Cathedral, Black Town, Madras, India	Mar. 1, 1879
47	DUNN, A. F., Poynton, Stockport, Cheshire	June 2, 1877
48	DURNFORD, H. ST. JOHN, Low Stublin Colliery, near Rotherham ...	June 2, 1877
49	EDGE, J. C., Thorpe House, Coalport, Salop	Dec. 5, 1874
50	EDGE, JOHN H., Coalport Wire Rope and Chain Works, Shifnal, Salop	Sept. 7, 1878
51	FAIRLEY, JAMES, Craghead and Holmside Collieries, Chester-le-Street	Aug. 7, 1880
52	FARROW, JOSEPH, Brotton Mines, Brotton, R.S.O.	Feb. 11, 1882
53	FERGUSON, D., Cadzow Colliery, Hamilton, N.B.	Dec. 8, 1883
54	FISHER, EDWARD R., Cleveland Terrace, Walters Road, Swansea ...	Aug. 2, 1884
55	FLETCHER, W., Brigham Hill, *via* Carlisle	Oct. 13, 1883
56	FORSTER, THOMAS E., Lesbury, R.S.O., Northumberland	Oct. 7, 1876
57	FRYAR, MARK, Denby Colliery, Derby	Oct. 7, 1876
58	GERRARD, JAMES, 19, King Street, Wigan	Mar. 3, 1873
59	GILCHRIST, J. R., Durham Main Colliery, Durham	Feb. 3, 1877
60	GOULD, ALEX., 6, Ellison Place, Newcastle-on-Tyne	Dec. 1, 1877
61	GREENER, HENRY, South Pontop Colliery, Annfield Plain	Dec. 11, 1882
62	GREENER, T. Y., Hucknall Torkard Collieries, near Nottingham ...	July 2, 1872
63	GRESLEY, W. S., Overseale, Ashby-de-la-Zouch	Oct. 5, 1878
64	GUTHRIE, J. K., South Normanton Coll., near Alfreton, Derbyshire...	Mar. 1, 1879
65	HADDOCK, W. T., Jun., Ryhope Colliery, Sunderland	Oct. 7, 1876
66	HAGGIE, PETER SINCLAIR, Gateshead-on-Tyne	April 14, 1883
67	HALLAS, G. H., Hindley Green Colliery, near Wigan	Oct. 7, 1876
68	HALSE, EDWARD, Arenig Mines, near Bala, North Wales	June 13, 1885
69	HAMILTON, E., Rig Wood, Saltburn-by-the-Sea	Nov. 1, 1873
70	HARRIS, W. S., Andrews House, near Gateshead-on-Tyne	Feb. 14, 1874
71	HEDLEY, E., Rainham Lodge, The Avenue, Beckenham, Kent ...	Dec. 2, 1871
72	HEDLEY, SEPT. H., East Gawber Colliery, Barnsley	Feb. 15, 1879
73	HENDERSON, C. W. C., The Riding, Hexham	Dec. 11, 1882
74	HENDY, J. C. B., Middle Bitchburn Colliery, Howden-le-Wear, *via* Darlington	Sept. 2, 1876
75	HENRY, GEO. J., the E.C. Powder Co., Limited, Stone, Kent ...	Nov. 19, 1881
76	HILL, WILLIAM, Carterthorne Colliery Offices, Witton-le-Wear ...	June 9, 1883
77	HOOPER, FRED. G., South Derwent Coll., Annfield Plain, Lintz Green	Feb. 14, 1885
78	HUMBLE, JOICEY, Wire Rope Manufac., Byker Ropery, Newcastle ...	Mar. 3, 1877
79	HUMBLE, ROBERT, Wire Rope Manufac., Byker Ropery, Newcastle...	Sept. 2, 1876
80	HUMBLE, STEPHEN, 5, Westminster Chambers, Victoria St., London, S.W.	Oct. 6, 1877

ELECTED.

81 JEFFCOCK, CHARLES E., Birley Collieries, Sheffield ... ... Feb. 10, 1883
82 JEPSON, H., 54, Old Elvet, Durham ... ... July 2, 1872
83*JOBLING, THOS. E., Croft Villa, Blyth, Northumberland ... ... Oct. 7, 1876
84 JOHNSON, F. D., Aykleyheads, Durham ... ... Feb. 10, 1883
85 JOHNSON, W., Abram Colliery, Wigan ... ... Feb. 14, 1874

86 KIRTON, HUGH, Waldridge Colliery, Chester-le-Street ... ... April 7, 1877

87 LAVERICK, JOHN WALES, Middridge, nr. Heighington, *via* Darlington Dec. 11, 1882
88 LEE, JOHN F., Castle Eden Colliery, County Durham... ... ... June 13, 1885
89 LIDDELL, J. M., 3, Victoria Villas, Newcastle-on-Tyne ... ... Mar. 6, 1875
90 LIDDELL, JOHN, Coal Owner, Newcastle-on-Tyne ... ... Dec. 11, 1882
91 LINDSAY, C. S., Usworth, *via* Washington, R.S.O., Co. Durham ... Mar. 4, 1876
92 LISLE, J., Washington Colliery, County Durham ... ... July 2, 1872
93 LIVEING, E. H., 52, Queen Anne Street, Cavendish Square, London, W. Sept. 1, 1877
94 LONGBOTHAM, R. H., Brynkinalt Colliery, Chirk, Wales ... ... Sept. 2, 1876

95 MACCABE, H. O., Russell Vale, Wollongong, New South Wales ... Sept. 7, 1878
96 MADDISON, THOS. R., Thornes, near Wakefield ... ... Mar. 3, 1877
97 MAKEPEACE, H. R., Medomsley, Lintz Green, Newcastle-on-Tyne ... Mar. 3, 1877
98 MARKHAM, G. E., Howlish Offices, Bishop Auckland ... ... Dec. 4, 1875
99 MATTHEWS, J., Messrs. R. & W. Hawthorn, Newcastle-on-Tyne .. April 11, 1885
100 MELLY, E. F., Griff Collieries, Nuneaton ... ... Oct. 5, 1878
101*MERIVALE, W., c/o Mackinnon and Mackenzie, Bombay ... ... Mar. 5, 1881
102 MILLER, D. S., Wirral Colliery Co., Limited, Neston, Cheshire ... Nov. 7, 1874
103*MILLER, N.... ... ... Oct. 5, 1878
104 MOORE, WILLIAM, Upleatham Mines, Upleatham, R.S.O. ... ... Nov. 19, 1881
105 MOREING, C. A., Suffolk House, Lawrence Pountney Hill, London, E.C. Nov. 7, 1874
106 MORISON, JOHN, Newbattle Collieries, Dalkeith, N.B. ... ... Dec. 4, 1880

107 ORNSBY, R. E., Delaval (Benwell) Colliery, Newcastle-on-Tyne .. Mar. 6, 1875

108 PALMER, HENRY, East Howle Colliery, near Ferryhill ... ... Nov. 2, 1878
109 PEAKE, C. E., Sleaford, Lincolnshire ... ... Nov. 3, 1877
110*PEASE, ARTHUR, M.P., Darlington ... ... Dec. 11, 1882
111 PHILLIPS, W. J., Ansley Hall Colliery, Atherstone ... ... June 9, 1883
112 PREST, J. J., 4, Loraine Terrace, Low Fell, Gateshead-on-Tyne ... May 1, 1875
113 PREST, T., Peases' West Collieries, Crook, by Darlington ... .. June 14, 1884
114 PRICE, S. R., Houghton Main Colliery, near Barnsley, Yorkshire ... Nov. 3, 1877
115 PRINGLE, JOS., Manager, Coxlodge Colliery, So. Gosforth, Newcastle Mar. 5, 1881
116 PROCTOR, C. P., Shibden Hall Collieries, near Halifax, Yorkshire ... Oct. 7, 1876
117 PROUD, JOSEPH, South Hetton Colliery Offices, Sunderland ... ... Oct. 14, 1882

118 RATHBONE, EDGAR P., 2, Great George Street, Westminster, London Mar. 7, 1874
119 REED, R., Cowpen Lodge, Blyth, Northumberland ... ... Feb. 3, 1877
120 RIDLEY, Sir MATTHEW WHITE, Bart., M.P., Blagdon, Northumberland Feb. 10, 1883
121 ROBINSON, FRANK, Norley Colliery, Wigan ... ... Sept. 2, 1876

ELECTED.

122 Robson, T. O., Bensham Terrace, Gateshead-on-Tyne ... ... Sept. 11, 1875
123 Routledge, W. H., Cliffe House, Clowne, Chesterfield ... ... Oct. 7, 1876

124 Saise, W., Manager E.I.R. Collieries, Giridi, Bengal, India ... ... Nov. 3, 1877
125 Sawyer, A. R., Ass. R.S.M., Basford, Stoke-upon-Trent ... ... Dec. 6, 1873
126 Scurfield, Geo. J., Hurworth-upon-Tees, Darlington ... ... Dec. 11, 1882
127 Shipley, T., Woodland Colliery Office, Woodland, Butterknowle, R.S.O., Co. Durham ... ... Aug. 2, 1884
128 Simpson, F. L. G., Peases' West Collieries, Crook, by Darlington ... Dec. 13, 1884
129 Smith, Thos. Reader, M.E., Thorncliffe Collieries, near Sheffield ... Feb. 5, 1881
130 Snowball, Joseph, Seaton Burn House, Dudley, Northumberland ... Feb. 10, 1883
131 Southern, E. O., Breeze Hill, Whitehaven ... ... Dec. 5, 1874
132 Spence, R. F., Cramlington ... ... Nov. 2, 1878
133 Still, F. M., 3, Queen Street, Cheapside, London .. .. Dec. 8, 1883
134 Stobart, F., Pensher House, Fence Houses ... ... Aug. 2. 1873
135 Stobbs, Frank, 1, Queen Street, Newcastle-on-Tyne ... ... Oct. 1, 1881
136 Stoker, Arthur P., Birtley, near Chester-le-Street ... ... Oct. 6, 1877

137 Telford, W. H., Hartford Coll., Cramlington, R.S.O., Northumberland Oct. 3, 1874
138 Thomas, W. W., M.E., Mineral Office, Cockermouth Castle ... ... Feb. 10, 1883
139 Thompson, Charles Lacy, Milton Hall, Carlisle ... ... Feb. 10, 1883
140 Todd, John T., Hetton-le-Hole, Fence Houses... ... ... Nov. 4, 1876

141 Vitanoff, Geo. N., Sofia, Bulgaria ... ... April 22, 1882

142 Walters, Hargrave, Birley Collieries, near Sheffield ... ... June 4, 1881
143 Walton, J. Coulthard, Writhlington Collieries, Radstock, *via* Bath Nov. 7, 1874
144* Ward, T. H., Assistant Manager, E.I.R. Collieries, Giridi, Bengal, India Aug. 7, 1882
145 Wardle, Edward, Craghead Colliery, Chester-le-Street ... ... Feb. 5, 1881
146 Watson, Robert, North Seaton, Morpeth ... ... Dec. 11, 1882
147 Webster, H. Ingham, Morton House, Fence Houses ... ... April 14, 1883
148 Weeks, R. L., Willington, Co. Durham ... ... June 10, 1882
149 White, C. E., Hebburn Colliery, near Newcastle-on-Tyne ... ... Nov. 4, 1876
150 Wilson, J. D., Ouston House, Chester-le-Street ... ... Sept. 11, 1875
151 Wilson, John R., Swaithe, near Barnsley ... ... June 9, 1883
152 Wormald, C. F., Cross House, Corbridge ... ... Dec. 8, 1883

Students.

		ELECTED.
1	ANDERSON, R. S., Elswick Colliery, Newcastle-on-Tyne	June 9, 1883
2	ATKINSON, A. A., South Church, Bishop Auckland	Aug. 3, 1878
3	BARRASS, M., Tudhoe Colliery, Spennymoor	Dec. 10, 1883
4	BAUMGARTNER, W. O., Trimdon Grange Coll., Co. Durham	Sept. 6, 1879
5	BELL, GEO. FRED., 25, Old Elvet, Durham	Sept. 6, 1879
6	BIRD, HARRY, Mexico	April 7, 1877
7	BLAKELEY, A. B., Hollyroyd, Dewsbury	Feb. 15, 1879
8	BRAMWELL, HUGH, Mining Offices, Marsden, South Shields	Oct. 4, 1879
9	CHANDLEY, CHARLES, Latchford, Warrington, Lancashire	Nov. 6, 1880
10	COLE, COLLIN, Simonside Cottage, Tyne Dock, South Shields ...	Oct. 18, 1882
11	CRAWFORD, JAMES MILL, Murton Colliery, near Sunderland ...	Dec. 11, 1882
12	CRONE, F. E., Killingworth House, near Newcastle-on-Tyne	Sept. 2, 1876
13	CURRY, W. THOS., Hamsteels Colliery, Durham	Sept. 4, 1880
14	DEPLEDGE, M. F., Tudhoe Colliery, Spennymoor	April 7, 1877
15	DOUGLAS, A. S., Stanley Villa, near Crook, *via* Darlington	June 1, 1878
16	EVANS, DAVID L., Messrs. Dalziel & Evans, Cardiff	May 4, 1878
17	FERENS, FREDERICK J., 220, Gilesgate, Durham	Dec. 4, 1880
18	FORSTER, C. W., 6, Ellison Place, Newcastle-on-Tyne...	June 10, 1882
19	GALLWEY, A. P., New Patori Gold Mine, 42, New Broad St., London	Oct. 2, 1880
20	GORDON, CHAS.	May 5, 1877
21	GREIG, J., Eston Mines, Middlesbro'-on-Tees	Feb. 5, 1881
22	HAGGIE, DOUGLAS, Thorncliffe Iron Works, Sheffield...	April 14, 1883
23	HAIG, R. NOBLE, 32, Rutland Street, Hampstead Road, London ...	Feb. 10, 1883
24	HARE, SAMUEL, Broughton and Plas Power Coal Co., Ld., Wrexham	Aug. 2, 1879
25	HARRISON, R. W., Public Wharf, Leicester	Mar. 3, 1877
26	HAY, W., Jun., Nostell Colliery, Wakefield	Dec. 10, 1883
27	HESLOP, SEPTIMUS, Assensole, Bengal, India	Dec. 4, 1880
28	HESLOP, THOMAS, Storey Lodge Colliery, Cockfield, *via* Darlington...	Oct. 2, 1880
29	HILL, LEONARD, Newport Wire Mills, Middlesbro'	Oct. 6, 1877
30	HOOPER, EDWARD, The Grange, Claines, Worcester	June 4, 1881
31	HOWARD, WALTER, Markham Colliery, Duckmanton, near Chesterfield,	April 13, 1878
32	HUDSON, JOSEPH G. S., Albion Mines, Pictou County, Nova Scotia...	Mar. 2, 1878
33	HURST, GEO., Seaton Delaval Colliery, Northumberland	April 14, 1883
34	HUTT, E. H., Usworth Coll., Washington Station, R.S.O., Co. Durham	Aug. 4, 1883
35	KAYLL, A. C., Felling Colliery, Gateshead-on-Tyne	Oct. 7, 1876
36	KIRKHOUSE, E. G., 1, Edith Street, Consett, Co. Durham	Aug. 3, 1878
37	KIRKUP, PHILIP, Radcliffe Colliery, Acklington, Northumberland ...	Mar. 2, 1878

		ELECTED.
38	LISHMAN, R. R., Celynen Colliery, Abercarne, *via* Newport, Mon. ...	June 9, 1883
39	LOCKE, E. G.	Dec. 2, 1876
40	MACKINLAY, T. B., West Pelton Colliery, Chester-le-Street	Nov. 1, 1879
41	MARSTON, FRANK, Bromfield Hall, Mold	Aug. 7, 1882
42	MCLAREN, B., Bedlington, R.S.O., Northumberland	Dec. 10, 1883
43	MCMURTRIE, G. E. J., 42, Clough Road, Masbro', Rotherham ...	Aug. 2, 1884
44	MITTON, A. D., Hetton Colliery, Fence Houses	June 9, 1883
45	MURRAY, W. C., Weed Park, Dipton, *via* Lintz Green Station ...	Oct. 4, 1879
46	MURTON, CHARLES J., Jesmond Villas, Newcastle-on-Tyne	Mar. 6, 1880
47	NICHOLSON, A. D., Eldon Colliery, Co. Durham	June 13, 1885
48	NICHOLSON, J. H., Cowpen Colliery Office, Blyth, Northumberland ...	Oct. 1, 1881
49	OATES, ROBERT J. W., E.I.R. Collieries, Giridi, Bengal, India ...	Feb. 10, 1883
50	PATTISON, JOS. W., Londonderry Offices, Seaham Harbour	Feb. 15, 1879
51	PEAKE, R. C., Highgate, Wallsall	Feb. 7, 1880
52	PEART, A. W., Mardy Colliery, near Pontypridd, Glamorganshire ...	Nov. 4, 1876
53	PEASE, J. F., Pierremont, Darlington	June 9, 1883
54	PIKE, ARNOLD, Furzebrook, Wareham, Dorsetshire	Feb. 5, 1881
55	POTTER, E. A., Cramlington House, Northumberland	Feb. 6, 1875
56	PRINGLE, H. A., Barrow Collieries, Barnsley, Yorkshire	Oct. 2, 1880
57	PRINGLE, HY. GEO., Tanfield Lea Coll., Lintz Green Station, Newcastle	Dec. 4, 1880
58	REDMAYNE, R. A. S., Hetton Collieries, near Fence Houses... ...	Dec. 13, 1884
59	RICHARDSON, RALPH, Field House, West Rainton, Fence Houses ...	June 9, 1883
60	RICHARDSON, R. W. P., Office of General Manager, Cedral Mining and Smelting Co.'s Mines, Villa de Musquiz Coalmila, Mexico ...	Mar. 4, 1876
61	RIDLEY, WM., So. Tanfield Coll., Stanley, R.S.O., Newcastle-on-Tyne	Dec. 11, 1882
62	ROBINSON, GEO.	Nov. 4, 1876
63	RUTHERFORD, R., So. Derwent Colliery, Annfield Plain, Lintz Green	Feb. 14, 1885
64	SCARTH, R. W., Dishforth, near Thirsk	Dec. 4, 1875
65	SCOTT, JOSEPH SAMUEL, East Hetton Colliery, Coxhoe, Co. Durham	Nov. 19, 1881
66	SCOTT, WALTER, 6, Sutton Street, Durham	Sept. 6, 1879
67	SCOTT, WM., Brancepeth Colliery Offices, Willington, Co. Durham ...	Mar. 4, 1876
68	SHUTE, WM. ASHLEY, Westoe, South Shields	April 11, 1885
69	SIMPSON, F. R., Hedgefield House, Blaydon-on-Tyne	Aug. 4, 1883
70	SMITH, THOS., Leadgate, Co. Durham	Feb. 15, 1879
71	SMITH, T. F., Jun., Lydbrook, near Ross, Herefordshire	May 5, 1877
72	SOUTHERN, THOMAS A., Cwmaman Colliery, near Aberdare, So. Wales	Dec. 17, 1881
73	STEAVENSON, C. H., Durham	April 14, 1883
74	STOBART, H. T., Mill View Cottage, Southwick, Sunderland ...	Oct. 2, 1880
75	TODNER, W. J. S.	Sept. 6, 1879
76	WAUGH, C. L., Ffalda Steam Coal Colliery, Garw Valley, nr. Bridgend	Nov. 19, 1881
77	YEOMAN, THOMAS, 1, Westfield Terrace, Loftus-in-Cleveland ...	Feb. 14, 1885

Subscribers under Bye-law 9.

1 Ashington Colliery, Newcastle-on-Tyne.
2 Birtley Iron Company, Birtley.
3 Haswell Colliery, Fence Houses.
4 Hetton Collieries, Fence Houses.
5 Lambton Collieries, Fence Houses.
6 Londonderry Collieries, Seaham Harbour.
7 Marquess of Bute.
8 North Hetton Colliery, Fence Houses.
9 Ryhope Colliery, near Sunderland.
10 Seghill Colliery, Northumberland.
11 South Hetton and Murton Collieries.
12 Stella Colliery, Hedgefield, Blaydon-on-Tyne.
13 Throckley Colliery, Newcastle-on-Tyne.
14 Victoria Garesfield Colliery, Lintz Green.
15 Wearmouth Colliery, Sunderland.

CHARTER

OF

THE NORTH OF ENGLAND

Institute of Mining and Mechanical Engineers.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING:

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased); THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased); SIR GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty-two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the Advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community; that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments

and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life; that the Society has held meetings at stated periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. AND WHEREAS in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of our Kingdom, we have been besought to grant to the said LINDSAY WOOD, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. NOW KNOW YE that we, being desirous of encouraging a design so laudable and salutary of our special grace, certain knowledge, and mere motion, have willed granted, and declared, and

do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said LINDSAY WOOD, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of us, our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes and mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectfully at the rack rent which might have been had or gotten for the same respectfully at the time of the purchase or acquisition thereof. AND WE DO HEREBY GRANT our especial licence and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments not exceeding with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements, or hereditaments not exceeding the like annual value. AND WE FURTHER will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. And our will and pleasure is, and we further grant and declare that for the better rule

and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. AND WE DO HEREBY FURTHER will and declare that the said LINDSAY WOOD shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectfully shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. AND WE DO HEREBY FURTHER will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. AND WE DO FURTHER will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held, and for convening the same and regulating the proceedings thereat, and

for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. AND WE DO FURTHER will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, provided always that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. IN WITNESS WHEREOF WE HAVE CAUSED THESE OUR LETTERS TO BE MADE PATENT.

Witness Ourself at our Palace, at Westminster, this 28th day of November, in the fortieth year of our reign.

By Her Majesty's Command.

CARDEW.

THE NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

BYE-LAWS

PASSED AT A GENERAL MEETING ON THE 16TH JUNE. 1877.

1.—The members of the North of England Institute of Mining and Mechanical Engineers shall consist of four classes, viz.:—Original Members, Ordinary Members, Associate Members, and Honorary Members, with a class of Students attached.

2.—ORIGINAL MEMBERS shall be those who were Ordinary Members on the 1st of August, 1877.

3.—ORDINARY MEMBERS.—Every candidate for admission into the class of Ordinary Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-eight years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other recognised branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least five years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have practised on his own account in the profession of an Engineer for at least five years, and have acquired a considerable degree of eminence in the same.

4.—ASSOCIATE MEMBERS shall be persons practising as Mining or Mechanical Engineers, or in some other recognised branch of Engineering, and other persons connected with or interested in Mining or Engineering.

5.—HONORARY MEMBERS shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or some other of the recognised branches of Engineering, and such persons may continue Students until they attain the age of twenty-three years.

7.—The annual subscription of each Original Member, and of each Ordinary Member who was a Student on the 1st of August, 1877, shall be £2 2s., of each Ordinary Member (except as last mentioned) £3 3s., of each Associate Member £2 2s., and of each Student £1 1s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

8.—Any Member may, at any time, compound for all future subscriptions by a payment of £25, where the annual subscription is £3 3s., and by a payment of £20 where the annual subscription is £2 2s. All persons so compounding shall be Original, Ordinary, or Associate Members for life, as the case may be ; but any Associate Member for life who may afterwards desire to become an Ordinary Member for life, may do so, after being elected in the manner described in Bye-law 13, and on payment of the further sum of £5.

9.—Owners of Collieries, Engineers, Manufacturers, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to a ticket to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible up to the number of ten persons ; and each such Subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Proceedings of the Institute sent to him.

10.—In case any Member, who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 8, and may thereupon constitute him a Life Member, or permit him to resume his former rank in the Institute.

11.—Persons desirous of becoming Ordinary Members shall be proposed and recommended, according to the Form A in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must be signed by the proposer and at least five other Members certifying a personal knowledge of the candidate. The proposal so made being delivered to the Secretary, shall be submitted to the Council, who on approving the qualifications shall determine if the candidate is to be presented for ballot, and if it is so deter-

mined, the Chairman of the Council shall sign such approbation. The same shall be read at the next Ordinary General Meeting, and afterwards be placed in some conspicuous situation until the following Ordinary General Meeting, when the candidate shall be balloted for.

12.—Persons desirous of being admitted into the Institute as Associate Members, or Students, shall be proposed by three Members; Honorary Members shall be proposed by at least five Members, and shall in addition be recommended by the Council, who shall also have the power of defining the time during which, and the circumstances under which, they shall be Honorary Members. The nomination shall be in writing, and signed by the proposers (according to the Form B in the Appendix), and shall be submitted to the first Ordinary General Meeting after the date thereof. The name of the person proposed shall be exhibited in the Society's room until the next Ordinary General Meeting, when the candidate shall be balloted for.

13.—Associate Members or Students, desirous of becoming Ordinary Members, shall be proposed and recommended according to the Form C in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must certify a personal knowledge of the candidate, and be signed by the proposer and at least two other Members, and the proposal shall then be treated in the manner described in Bye-law 11. Students may become Associate Members at any time after attaining the age of twenty-three on payment of an Associate Member's subscription.

14.—The balloting shall be conducted in the following manner:—Each Member attending the Meeting at which a ballot is to take place shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the Form D in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members voting.

15.—Notice of election shall be sent to every person within one week after his election, according to the Form E in the Appendix, enclosing at the same time a copy of Form F, which shall be returned by the person elected, signed, and accompanied with the amount of his annual subscription, or life composition, within two months from the date of such election, which otherwise should become void.

16.—Every Ordinary Member elected having signed a declaration in the Form F, and having likewise made the proper payment, shall receive a certificate of his election.

17.—Any person whose subscription is two years in arrear shall be reported to the Council, who shall direct application to be made for it, according to the Form G in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter, according to the Form H in the Appendix, of declaring that the defaulter has ceased to be a member.

18.—In case the expulsion of any person shall be judged expedient by ten or more Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half the Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the Form I in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion; and if a majority of the persons present at such Meeting (provided the number so present be not less than forty) vote that such person be expelled, the Chairman of that Meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the Form J in the Appendix.

19.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Original, Ordinary and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council. The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election, with the exception of any President or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest Council Meetings during the past

year; but such Members shall be eligible for re-election after being one year out of office.

20.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

21.—Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The Votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a list of persons whom they nominate as suitable for the vacant offices, and a new Officer or Officers shall be elected at the succeeding Ordinary General Meeting.

23.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

24.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member present, to take the chair at the meeting.

25.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating specific subjects connected with the objects of the Institute. Such Committees shall report to the Council, who shall act thereon as they see occasion.

26.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

27.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

28.—The Copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

29.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council. A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

30.—At meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members.

31.—All Past-Presidents shall be *ex-officio* Members of the Council so long as they continue Members of the Institute, and Vice-Presidents who have not been re-elected or have become ineligible from having held office for three consecutive years, shall be *ex-officio* Members of the Council for the following year.

32.—Every question, not otherwise provided for, which shall come before any Meeting, shall be decided by the votes of the majority of the Original, Ordinary, and Associate Members then present.

33.—All papers shall be sent for the approval of the Council at least twelve days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and notice shall be given to the writer within one month after it has been read, whether it is to be printed or not.

34.—All proofs of reports of discussions, forwarded to Members for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

35.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

36.—Twelve copies of each paper printed by the Institute shall be presented to the author for private use.

37.—Members elected at any meeting between the Annual Meetings shall be entitled to all papers issued in that year, so soon as they have signed and returned Form F, and paid their subscriptions.

38.—The Transactions of the Institute shall not be forwarded to Members whose subscriptions are more than one year in arrear.

39.—No duplicate copies of any portion of the Transactions shall be issued to any of the Members unless by written order from the Council.

40.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote. Any Member of the Institute shall also have power to introduce two strangers (see Form L) to any General Meeting, but they shall not take part in the proceedings except by permission of the Meeting.

41.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

Approved,
R. ASSHETON CROSS.

Whitehall,
2nd July, 1877.

APPENDIX TO THE BYE-LAWS.

[FORM A.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being upwards of twenty-eight years of age, and desirous of being elected an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him from *personal knowledge* as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed_____ Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an ordinary Member.

FROM PERSONAL KNOWLEDGE.

_____
_____
_____ } Five Members.
_____
_____

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a of the North of England Institute of Mining and Mechanical Engineers.

Signed_____ Chairman.

Dated this day of 18

[FORM B.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of admission into the North of England Institute of Mining and Mechanical Engineers, we, the undersigned, propose and recommend that he shall become [an Honorary Member, or an Associate Member, or a Student] thereof.

_____
_____
_____ } Three* Members.
_____
_____

* If an Honorary Member, five signatures are necessary, and the following Form must be filled in by the Council.

Dated this day of 18

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Honorary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed _____ Chairman.

Dated day of 18

[FORM C.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being at present a of the North of England Institute of Mining and Mechanical Engineers, and upwards of twenty-eight years of age, and being desirous of becoming an Ordinary Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the Qualifications of the Candidate according to the spirit of Bye-law 3.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed _____ Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being

convinced that A. B. is in every respect a proper person to be admitted an Ordinary Member.

FROM PERSONAL KNOWLEDGE.

_____ } Two
_____ } Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed _____ Chairman.

Dated day of 18

[FORM D.]

List of the names of persons to be balloted for at the Meeting on , the day of 18

ORDINARY MEMBERS:—

_____

_____

_____

ASSOCIATE MEMBERS:—

_____

_____

HONORARY MEMBERS:—

_____

_____

STUDENTS:—

_____

_____

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

[FORM E.]

SIR,—I beg leave to inform you that on the day of you were elected a of the North of England Institute of Mining and Mechanical Engineers, but in conformity with its Rules your election cannot be confirmed until the enclosed form be returned to me

with your signature, and until your first annual subscription be paid, the amount of which is £ , or, at your option, the life-composition of £

If the subscription is not received within two months from the present date, the election will become void under Bye-law 15.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM F.]

I, the undersigned, being elected a of the North of England Institute of Mining and Mechanical Engineers, do hereby agree that I will be governed by the Charter and Bye-laws of the said Institute for the time being; and that I will advance the objects of the Institute as far as shall be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to be a Member.

Witness my hand this day of 18

[FORM G.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 17, and to remind you that the sum of £ of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, Sir,

Yours faithfully,

Secretary

Dated 18

[FORM H.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you, that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 17, the Council have determined that unless payment of the amount £ is made previous to the day of next, they will proceed to declare that you have ceased to be a Member of the Institute.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM I.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 18.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM J.]

SIR,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of the North of England Institute of Mining and Mechanical Engineers, held on the day of 18 , according to the provisions of Bye-law 18 you have ceased to be a Member of the Institute.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM K.]

BALLOTING LIST.

Ballot to take place at the Meeting of 18 at Two o'Clock.

PRESIDENT—ONE NAME only to be returned, or the vote will be lost.

——— President for the current year eligible for re-election.

——— } New Nominations.

VICE-PRESIDENTS—SIX NAMES only to be returned, or the vote will be lost.

The Votes for any Members who may not be elected as President or Vice-Presidents will count for them as other Members of the Council.

——— } Vice-Presidents for the current year eligible for re-election.

——— } New Nominations.

COUNCIL—EIGHTEEN NAMES only to be returned, or the vote will be lost.

——— } Members of the Council for the current year eligible for re-election.

——— } New Nominations.

Any list returned with a greater number of Names than
ONE PRESIDENT,
SIX VICE-PRESIDENTS,
EIGHTEEN COUNCILLORS,
Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

Extract from Bye-law 21.

Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the Offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days

previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the Scrutineers. The votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four Scrutineers, who shall receive the balloting papers, and after making the necessary scrutiny destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the Scrutineers for the election of Officers.

_____

_____

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Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 19:—

As President _____

As Vice-President _____

As Councillors _____

[FORM L.]

Admit

of

to the Meeting on Saturday, the

(Signature of Member or Student)

The Chair to be taken at Two o'Clock.

I undertake to abide by the Regulations of the North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor)

Not transferable.

NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING, SATURDAY, OCTOBER 11TH, 1884, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

JOHN DAGLISH, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were nominated for election :—

ASSOCIATE MEMBER—

Mr. F. L. G. SIMPSON, Pease's West Collieries, Crook, by Darlington.

STUDENT—

Mr. R. A. S. REDMAYNE, Hetton Collieries, near Fence Houses.

Mr. S. F. WALKER read the following paper "On the Principles of Electric Lighting, and the Construction and Arrangement of Electric Light Apparatus":—

ON THE PRINCIPLES OF ELECTRIC LIGHTING, AND THE CONSTRUCTION AND ARRANGEMENT OF ELECTRIC LIGHT APPARATUS.

By SYDNEY F. WALKER, M.S.T.E. and E., M.I.M.E.

In a practical paper one is hardly concerned with the question of what electricity is, but only with what results can be obtained by its use; still it may not be amiss to point out, that although electricity is probably produced in every action of every body that exists, yet for its practical application it is necessary that energy should be expended on some body or substance before any electrical work can be done, whether the results of that work be in the form of heat, light, or motive power. Electricity may be produced in, at present, four different ways.

1. By friction, as in the old experiment of rubbing a glass rod with a silk handkerchief.
2. By the direct action of heat on one set of junctions of a series of pairs of dissimilar metals.
3. By the consumption of zinc, or some other oxidizable substance, in a galvanic battery.
4. By the direct action of mechanical power, causing a series of conductors to pass through a magnetic field.

Before proceeding further, it will perhaps be best to define the terms that will be used in the course of the paper.

Conductors.—All known substances allow of the transmission of an electric current through them, but not with the same facility; while the metals allow its passage very freely, other substances, such as cotton, silk, glass, India-rubber, gutta-percha, &c., only allow it with great difficulty; hence the former substances have been termed conductors, and substances partaking of the electrical properties of the latter have been termed insulators; a few substances, such as carbon, silicon, and some of the oxides, occupy a position between these two in the scale, and hence have been termed semi-conductors.

Conductors themselves, though their conducting power when referred to that of insulators is practically infinite, differ very considerably in conductivity relatively to each other. Thus, copper has about six times the conducting power of iron and seventeen times that of platinum. Again, the conducting power of each substance depends on its form; thus, a long conductor of a given section will require the expenditure of a greater amount of work, or a greater force to pass a current of a certain strength through it than a short conductor of the same section. A thin wire of a given length will in the same way conduct less easily than a thick wire. Thus, it may happen that a large mass of a very bad conductor, such for instance as water, in the form of a broad deep stream, may conduct infinitely well, while a good conductor of very small section may offer a very high resistance.

RESISTANCE.—This term expresses simply the reverse of conducting power. A substance that has a high conducting power offers a low resistance, or as it is termed, has a low specific resistance. A substance that conducts badly is said to have a high resistance. Resistance corresponds to inertia in mechanics; it is the property by reason of which work has to be done by an electric current in passing through a body, or from one point to another.

An ELECTRIC CURRENT is merely the passage of electricity through a body or series of bodies.

The ELECTRIC CIRCUIT is the path by which the current travels, and one peculiarity of electro-dynamic action is, that no electric current will pass unless there is a complete path or circuit extending from a point in the generator and returning to it again, *and including the generator itself.* An electric circuit may be made up of a number of branches spreading out from a point or points and returning to the main circuit at other points; such paths are known as derivations or multiple arcs.

ELECTRO-MOTIVE FORCE corresponds to pressure in steam, and with water-power, or to temperature in heat; it is the force by reason of which an electric current is obtained. The ratio of the electro-motive force to the resistance determines the strength of the electric current passing in any circuit, or between any two points in a circuit. This is usually expressed by what is known as Ohm's law; viz., the strength of the current passing in any circuit, or between any two points in a circuit, varies directly as the electro-motive force, and inversely as the resistance, or shortly $C = \frac{E}{R}$, where C = current strength in ampères, E = electro-motive force in volts, R = resistance in ohms. A definition of these terms is now necessary.

The AMPÈRE is the unit of current strength. There is a current of one ampère when the unit quantity, the COULOMB passes in one second, or mathematically, it is the current passing in a circuit whose resistance is one ohm under an electro-motive force of one volt.

The VOLT is the unit of electro-motive force; it is very nearly the force of the Daniel's cell, and two-thirds that of the Le Clanché.

The OHM is the unit of resistance; it is equal to the resistance of about one mile of No. 4 old Birmingham wire-gauge copper wire, or of 150 yards, roughly, of No. 16 pure copper wire; it may be also designated as the resistance of a column of mercury 1·0624 metre in length, and 1 square millimetre in section.

Whenever an electric current passes through a body it does work in the form of heat; that is, it generates heat in the body. The amount of heat generated or work done will always be proportional to the electro-motive force, and to the current strength, or to E × C. It is also equal to the square of the current strength × resistance, and to the square of electro-motive force ÷ resistance.

The unit of work is the WATT; it is the work done when a current of one ampère passes between two points, having an electro-motive force or difference of tension of one volt, or a resistance of one ohm. It equals $\frac{1}{746}$ h.p.

Of the different methods of generating electricity, only the last need be considered here. The direct conversion of mechanical energy applied to the pulley of a dynamo into electrical energy in the form of a current, by the rapid passage of a series of conductors through a magnetic field.

Everyone is familiar with the properties of the ordinary steel magnet, consisting of a piece of steel that has been rubbed with a substance possessing magnetic properties. It will, if free to do so, place itself in line with the earth's magnetic axis, and one pole will, if allowed, dip towards the earth's magnetic North or South Pole. It has the property of attracting iron and steel, and of, more or less temporarily according to the nature of the substance, imparting to them its own magnetic properties. Certain points called poles usually near its ends have opposite properties, that pole which turns north, if freely suspended, exerting a repelling force on a pole having a similar tendency, and attracting that which turns south, and *vice versâ*.

These properties are not confined to the immediate neighbourhood of the magnet; they extend for a certain space around, according to the strength of the magnet and the position of surrounding bodies. A magnet may be able to set up a state of tension in a neighbouring

magnetic body, making it necessary that more work shall be done in moving it than when the magnet was not there. The space thus influenced is called the magnetic field. It is obvious that a magnetic field may be produced by the action of more than one magnet. In fact, the effect upon any bodies, magnetic or conducting, is the resultant of the forces exerted by all the magnets in the field. It is found, by the familiar experiment with iron filings, that the influence exerted by each magnetic pole, or group of poles, is directed in certain lines radiating in curves from the poles; these lines have been termed by Faraday "lines of force," and he conceived the idea of measuring the strength of a magnetic pole or field by the number of these lines in a given space.

The direction of the lines of force in any given part of the field is such that a small magnet or piece of iron capable of magnetism would, if free to move, place itself coincident with the line of force at that point. It will be evident that as these lines of force are really the direction in which the influence of the magnet acts, every additional magnet pole that is brought into the field will modify the direction of these lines, since it will exert its own influence as though the original magnet had not been there, the body to be influenced obeying the resultant of the forces. It is found also that the presence of a piece of iron, not capable itself of receiving permanent magnetism, materially modifies the direction of the lines by drawing them towards itself, and it follows as a matter of course, that the nearer it is to any particular pole, the more it will influence the lines of force emanating from that pole; further, also, since the attraction between the magnet and its keeper is mutual, the larger it is, within certain limits, the greater will be its influence upon the direction of the lines of force in that portion of the magnetic field in which it is placed.

Now it is found that, given a magnetic field, any disturbance in that field generates, or rather induces, momentary currents of electricity in any conductors that are present in the field.

Such disturbances may be caused by—

1. The motion of the conductor itself in the field.
2. The motion of one or more of the magnets.
3. The sudden loss by one or more of the magnets of its magnetic power.
4. The sudden creation of a magnet within the field.
5. The increase or decrease of the power of one or more of the magnets.

To whatsoever cause it is due the result is the same, viz., a current of momentary duration is induced in every conductor of electricity present

in the field. The strength of this current in each conductor, like every other obeying Ohm's law, defined above, is proportional to the electro-motive force developed, divided by the resistance of the conductor itself.

The electro-motive force developed depends upon the strength of the magnetic field, or the number of lines of force that are disturbed in the neighbourhood of the conductor; the direction in which the disturbance, whatever it may be, causes the lines of force to be cut by the conductor; and the rapidity with which the disturbance is effected.

It is found experimentally that the more nearly the angle at which the lines pass through the conductor approach a right angle, the greater is the electro-motive force produced, other things being the same; in all dynamos, therefore, every effort is made to cause the lines of force to be cut actually at right angles, and to have as many turns of wire as possible passing through the field in a given time. In all dynamo machines the method adopted is to cause either a series of coils of wire to pass through a powerful magnetic field, or to cause a magnet, or series of magnets, to pass rapidly in the neighbourhood of the coils of wire. With a few exceptions that will be detailed, the former plan is almost universally adopted.

An insulated conductor, usually a copper wire covered with cotton or silk, is coiled a great number of times on itself, and is then mounted for convenience on some kind of framework, and caused to revolve rapidly in a magnetic field prepared for it.

MACHINES.

The whole of the different arrangements of dynamo and magneto-electric machines that have paid such handsome royalties to Her Majesty's Patent Office are merely different arrangements, designed to effect by different means, the more perfect conversion of the mechanical energy delivered to the machine into electrical energy, and to reduce as much as possible both the charge made for conversion and the charge made by the machine itself upon the current passing through it.

In some cases a better arrangement of the inducing, or field magnets as they are called, is the great feature; more frequently it is a different arrangement of the wires on the moving portion or armature, or a different arrangement of wire and iron core of the armature, or a special arrangement of the iron core itself, designed the better to ensure that it, being a conductor moving in the magnetic field, shall receive the very smallest current that is possible.

It will be remembered that it was pointed out how the presence of a piece of iron, itself incapable of receiving permanent magnetism, affected the direction of the lines of force by bending them towards itself.

With the exception of a few special types, the armatures of all dynamo and magneto-electric machines consist of some form of electro magnet; some arrangement involving a core of iron, wrapped with a continuous length of cotton-covered copper wire. The core performs the very useful office of bending the lines of force towards it, so that they pass through the revolving wires at the best angle, viz., at, or nearly at, right angles. It is necessary, however, that this core should be specially constructed to offer no path, or at best, a path of very high resistance indeed, to the passage of the currents that will be induced in it, as well as in the wire coils, as it passes through the field. As the core, for the greater part of its revolution, usually moves parallel to the lines of force, these currents would, at best, be very small; but as even a small percentage is grudged, and as they would tend to additionally heat the armature and thereby, as will be explained, lower its capacity, every possible precaution is taken to reduce them.

A description of these different precautions will be best given with the machines themselves.

In the GRAMME machine, which was the first to solve in a practical form the problem of furnishing a continuous current from a dynamo machine, the core is formed of a long length of thin iron wire, made into a coil with its ends free, so that any current passing in it would not have an easy path; Fig. 1, Plate I. At right angles to the winding of the iron wire are wound the coils, as shown in Fig. 2. The whole circumference of the iron coil is filled with these coils of copper wire, which are connected to each other in series, the near ends of adjacent coils being joined. The bobbin, as it is now termed, is then wedged on a wood hub, which is keyed on a steel spindle. On the same spindle is mounted the commutator, one of the most important parts of the whole apparatus, which consists of a hollow cylinder, *a*, Fig. 3, built up of a number of copper segments, equal in number to the coils on the ring, each insulated from its neighbour, and the whole carefully insulated from the spindle by rings of very strong insulating material specially turned for the purpose. Each segment carries a radial arm, *b*, and to this arm the projecting ends of the coils are soldered. A binder of tape and wire *c*, is put on outside the wire coils to prevent them expanding by heat or centrifugal force sufficiently to cut themselves on the poles of the machine. The whole is screwed together with locking nuts, and is ready to go into its place in the machine.

Fig. 4, shows an A. Gramme bobbin on its spindle complete. A pulley is usually keyed on one end of the shaft, by means of which the power

can be delivered to the dynamo; it can also be delivered by gearing, direct coupling, or any other convenient method. Where the spindle is coupled direct to that of the engine or other motor, the latter must revolve at the same speed as the armature of the dynamo.

The field magnets in the Gramme continuous current machines are formed of two pairs of bar magnets, the like poles of each pair uniting to form a powerful north pole on one side and a south pole on the other. To the central junction of each pair are attached cheeks which embrace the armature together for two-thirds of its circumference. The magnets themselves are held together by cast-iron side pieces, which carry the bearings for the spindles to run in, the lubricators, and the brush holders. Figs. 4 and 5, Plate I., show complete machines of the A and B type. The brush holders *a a*, just mentioned, are merely sockets that hold brushes, and are attached to the frame of the machine. The brushes are made of a number of fine wires soldered together at one end; the other end with its loose wires is made to rest tightly on the commutator *b*, and to take off the current from it as the armature revolves. There are two brushes, one on each side, which receive currents of opposite name, from opposite sides of the machine. Each coil furnishes a current in one direction, in passing through one-half of its revolution, cutting those lines of force in which the influence of the north pole predominates. In the other half it furnishes a current in the opposite direction, where it is cutting those lines of force in which the influence of the south pole prevails. The brushes are placed just at the neutral point, so that the current is delivered to the brush at its strongest, and just before it would be reversed if not taken off. Small sparks pass between the brushes and the commutator, due to the breaking of the current. The brushes gradually wear away and are fed outwards from the holder, so as always to present a clean surface. A spring and a screw regulate the pressure of the brushes on the commutator. The two currents being in opposite directions at their respective brushes are in the same direction with respect to the complete circuit (see Fig. 6). The current setting out from the + brush* passes through the external circuit of lamps, etc., comes to the — brush (after passing through the electro-magnets, if self-exciting, as will be explained) then divides between the two halves of the ring, so that the current which is being continually furnished is always passing through the coils of the armature itself; the latter forming as much a part of the circuit as the lamps, wires, or any other

* For the purpose of the paper it is assumed that the electric current passes from + to — in any circuit, or from points at higher tension to those at lower.

portion of the apparatus. Currents are furnished when the external circuit is not closed or the brushes are in contact with the commutator ; but being equal and opposite, they neutralise each other.

There are two principal types of the Gramme machine at present constructed, the A and the B types, shown by Figs. 4 and 5. The only difference is that in the A the electro-magnets are round, and in the B they are flat; and that the bobbin or armature in the B is very much larger than that in the A. There is now also an intermediate machine called the A A, of a very similar pattern to the A, but in which the electro-magnets and bobbin are slightly elongated. This machine does about 50 per cent. more work than the A.

In the SIEMENS direct current machine, what is thought by some electricians to be a defect in the Gramme, was sought to be remedied. It has been thought that the wire on the inside of the coils in the Gramme armature, that next the wood "hub," does no work, or that if it does any, that it is the reverse of beneficial, being on the opposite side of the coil ; whether this is so or not is exceedingly difficult to prove, no one appears to have satisfactorily done so yet, and meanwhile the Gramme is apparently quite as efficient a machine as the Siemens.

In the Siemens machine the armature is elongated to the form of a long cylinder, and all the wire is wound on the outside ; there can be no doubt that the whole of the wire, with the exception of the small portion crossing the ends, is doing good service, but the writer thinks the arrangement presents some disadvantages. In his opinion, both mechanical strength and good insulation are neither so easily or so fully attained as with the Gramme, nor can the complete sub-division of the core be arranged so well. As against this, in some of the direct current machines (Siemens) the writer understands that the core is stationary, the drum with its coiled wire only revolving. This presents two distinct advantages, namely, that the weight of the core, a considerable item in large machines, has not to be moved, and, in addition, there are not the frequent changes of magnetism that take place in a revolving core ; involving an additional loss by heating of the core, and limiting its working capacity.

The commutator of the Siemens machine is precisely the same as the Gramme, except that the segments are movable and screwed down to a cylinder of insulating substance. The coils, too, not standing out in this form, as they do in the Gramme, no projecting radial pieces are required; the ends of the coils *c*, which are usually much fewer in number than in the Gramme, are screwed to the commutator segments *b*. Fig. 1, Plate II., shows a Siemens bobbin complete.

The Siemens machine, also, has a different arrangement of electro-magnets, though the same result is arrived at. Four flat bars *a a a a*, each carrying a coil of wire, are connected longitudinally two and two by bars *b b*; the pairs of magnets are arranged one on each side of the armature, the bars being bent to receive it, as shown in Fig. 2. The bars form on one side a powerful north pole and on the other a powerful south pole. The arrangement of the brushes only differs from those of the Gramme that have been sent out up to the present, in that, while the Gramme brush holder is a fixture, that of the Siemens can be revolved round the axis of the machine. The object is to lessen the sparking at the brushes, by arriving more correctly at the neutral point.

Figs. 3 and 4 show two types of Siemens machines, the vertical and the horizontal. It should be noted here that a Gramme armature would work equally well with field magnets of the Siemens type, and *vice versâ*, and patents have been taken out for both these modifications.

Messrs. Thomson and Houston, of America, have carried the objection named, that a part of the wire on the coils did no work, to its logical conclusion by having a spherical armature completely surrounded by electro-magnets. Fig. 5.

To clear the ground, perhaps it is better, before passing to more novel types, to give brief descriptions of two machines that are, in the writer's opinion, to a large extent copies of the Gramme and Siemens.

The MAXIM machine consists merely of an elongated Gramme bobbin revolving in the field produced by electro-magnets that are exact copies of those of the Siemens type. The writer understands that it has been claimed as a speciality for the Maxim machine that having two commutators, two distinct circuits can be taken from it; that is, one at each end of the armature, the alternate coils being brought to opposite ends. Many of the earlier Gramme machines were constructed in this way, and were even made to furnish currents differing in strength and electro-motive force. So far from its being an advantage, the writer would rather characterize it as the reverse; as in case the two circuits were not equally balanced, a sudden change in one might, by induction, seriously affect the other.* With regard to the construction of the armature, in the writer's opinion, it intensifies what are thought to be the faults of the Gramme. The amount of wire on the inside of the coils is much greater than in the Gramme, and while the core is heavier, it has not such a good chance of being properly divided up.

* A striking instance of this was mentioned at the recent Congress of Electricians at Philadelphia.

The WESTON machine, a Siemens armature, revolves in a field formed by electro-magnets constructed on the Gramme type. The core is built up of a series of iron discs perforated with holes and insulated from each other. In the later machines flat magnets of the Siemens type are used. A very close copy of this machine is now being made in England. The magnets and armature are exactly the same, except that the winding is ring fashion, as in the Gramme, and the whole surface is not covered. Recesses are cut in the discs for the reception of the wire. Fig. 1, Plate III.

The EDISON machine, Fig. 2, consists of a Siemens armature constructed specially of copper bars, or very thick copper wire, in order to carry large currents, running in a very powerful field formed by four, six, or more heavy electro-magnets stepping into very heavy iron pole pieces that closely embrace the armature. Its great merit, in the writer's opinion, consists in the large and powerful electro-magnets used to get a strong magnetic field, and in the ingenious construction of the armature. It is noteworthy, however, that in a recent improvement stated to have been made in the Edison machines by an eminent electrician, the field magnets have taken the shape they would have taken had it been an immense Gramme made upon the lines of existing machines. The great feature of the Edison machine is that it is designed for very large work, such as lighting portions of towns, &c.; so far as the writer is advised, the smaller machines do not come up to the other types.

The BÜRGIN, Fig. 3, is the next machine demanding special notice. In this quite a new departure has been taken. The magnets are similar to those of Siemens and later of Weston's, but made very strongly indeed. The armature consists of a series of wire hexagons, Figs. 4 and 5; a coil being wound on each section of each ring, Fig. 4. The rings are supported by radials forming hexagonal wheels, fixed laterally on a shaft, one behind the other, and the coils are arranged so that in the revolution each one is a little behind its neighbour in front, and before its neighbour behind. The coils are connected to each other like the coils in the Gramme ring; the series running from the commutator *b*, which is, as usual, on one end of the spindle, backwards to each coil in succession, the last of one row joining to the first of the next, and so on. Very good work has been done with these machines, but they are not generally considered so efficient as the Gramme and Siemens.

The GÜLCHER, Fig. 6, has few special features. Its armature is a wedge-shaped Gramme, and the Polar extensions take the form of a shoe embracing it. By this arrangement the objectionable feature mentioned in the Gramme

is certainly avoided, namely, all the wire is brought under the influence of the magnet. Mr. Gülcher also prefers to have four pairs of electro-magnets instead of two, and four brushes, each brush collecting the current as the coils pass out of the influence of that magnet. The machine does its work remarkably well, so far as the writer's experience goes at present. For some time the owners of the patent would only construct it to give a certain low electro-motive force to fit their own incandescent lamps, which rendered the use of the machine very expensive in other ways, as will be explained. The writer believes this error has now been remedied.

The SCHUCKERT machine is almost identical with the Gramme, the only difference, which is considered an improvement, being that the armature is made flat, and that the pole pieces extend on each side, so that very nearly all the wire is faced by it.

In a late improvement of this machine by the engineer of the Brush Company, he has suppressed nearly the whole of the pole pieces. Great things are claimed for the VICTORIA machine, as it has been named; but in the writer's opinion they do not accomplish anything that other types will not.

The BRUSH machine, Fig. 1, Plate IV., of which so much has been heard, stands quite by itself. There is no other machine like it. The armature is as nearly as possible the Pacinotti ring, which is described so fully in the text books. A heavy annular disc of iron is recessed for the reception of the wire coils at six, eight, or more places in its circumference. These coils do not consist, as in other types, of a number of short lengths of wire forming one continuous length; each is complete in itself. Nor is the collection the same. Each coil practically forms, with the coil on the opposite side of the disc, one machine, quite independent of all the other coils. Each coil consists of a long length of wire, carefully laid in the recess formed for it, and its inner end is joined to that of the opposite coil, while the outer end is connected to the commutator.

There are thus, in the Brush machine, virtually as many independent machines as there are pairs of coils. The disc is secured to a long spindle, running horizontally in bearings at each end of the machine, Fig. 2, the armature revolving in a vertical plane, in a space formed for it between the polar extensions of two pairs of very powerful electro-magnets, *d d*. The magnetic field in which the armature revolves is thus rendered very intense, and it is very doubtful if any of the lines of force are not cut by the revolving coils. Fig. 4 shows the arrangement. The armature disc is also scored, as shown in Fig. 1, both to lighten it

and to lessen the currents that are induced in it. The heavy mass of undivided metal in the Brush armature is, in the writer's opinion, a serious defect. It is a significant fact that the iron of the disc becomes very hot, while the wire of the coils remains perfectly cool.

It has always appeared to the writer that, with the arrangement of the field in the Brush machine, or with a slight modification thereof, it should be possible and profitable to do away with the iron disc and substitute a carrier disc of non-conducting material.* The arrangement of the commutator, Fig. 4, is really the special feature of the Brush machine. Each pair of coils has a solid copper ring, *e e*, running on the axle, for its own use. All of these rings are insulated from each other, and from the body of the machine, and they are, moreover, divided, as shown in Figs. 3 and 5, into four parts, two being sectors of about 150 degrees, *e e*, and the remainder of 30 degrees, *u u*. The larger sectors are in connection with the ends of the coils, as shown in Fig. 3, where the connections are traced out. The small sectors are not connected to anything. The large sectors face each other on the spindle, as also do the small sectors. A pair of brushes, *a a*, one on each side, bear lightly on each ring, collecting the current, not, as in other machines, at its best point, but as long as it is furnishing any to advantage, only there are now half as many pairs of brushes as there are pairs of coils, each collecting the current from two pairs.†

In this form each ring is always under its own brush, not, as in other machines, only under the brush during delivery. At the time when, in other machines, the coil would pass under the brush, and deliver its current previous to reversing the direction of the current flowing in it, in this the brush on each side passes on to the small sector, which, it will be remembered, is not connected to anything, so that the coils belonging to that ring are disconnected during the time that the small sectors are

* The writer learns that in the most recent patterns of Brush armatures, the weight of the disc is very considerably reduced; it being now, though still constructed of iron, more nearly a carrier for the coils.

† In Gramme, Siemens, and other machines, the coils are all connected together, and in each half, every coil is doing something which goes to swell the total strength of the current which the coil under the brush is delivering up.

In the Brush, each pair of coils acts quite independently of the others. It has its own commutator, and its own pair of brushes, with which it is continually in connection, and to which it is continually delivering up its current during the whole revolution, except the small interval when the lesser segments, marked *u*, Fig. 5, Plate IV., are under the brushes. During this period the ends of the coils are disconnected altogether, and the time of their being so disconnected is made to coincide with the time when the coil is passing through that portion of the magnetic field in which there are few lines of force,

under the brushes. This period corresponds to the time during which the coils are furnishing little or no current, and when they are doing very little useful work. This arrangement relieves the circuit of the resistance of each pair of coils in succession, a consideration in this machine, and tends to keep the coils themselves cooler. Each coil that is furnishing any current is made to pour it into the circuit, so that the total electro-motive force produced is the algebraical sum of the electro-motive forces produced by each coil.

The current produced, though practically uniform to all but delicate instruments, is by no means so in reality; and, in the writer's opinion, the irregularity is a serious evil when the machine is used in connection with incandescent lamps.

As to the dangers attending the use of the Brush machine it is not the arrangement, *per se*, that is dangerous, but the high tension with which the owners of the patent have up to the present insisted in working their machines. Any of the machines that have been described could easily have been made to deliver tensions equal to those furnished by the largest Brush machines. In fact, M. Marcel Deprez, the eminent French electrician, who has been experimenting so successfully on the electric transmission of power to long distances, has used Gramme machines constructed to give very much higher tensions than the latter, which are smaller than those Brush machines that are so dangerous. The writer is not aware of a single instance in this country where the high tension has been of the slightest benefit. It is, on the contrary, a constant source of danger to those ignorantly touching parts of the apparatus, and must also have been troublesome in the matter of insulation. Taking Ohm's law quoted above, it is easily seen that a substance may be practically a good insulator so long as the electro-motive force does not exceed a certain figure, yet may break down altogether if exposed to an electro-motive force several times as great. This applies to the human body. The resistance of the human body from foot to hand,

and where, therefore, the electro-magnetic force furnished would be so small as to lessen instead of increasing the total current. The current delivered by the Brush machine is from this cause very variable, its strength being made up of the algebraical sum of a number of minor currents, whose strength varies at each part of the revolution. Each pair of coils has its inner ends connected together, the outer ends being connected to the pieces *e*, Fig. 5. The commutator rings are put on the axle in pairs, and one set of brushes serves two rings, or two pairs of coils. This lessens the variation of the current strength, as the two coils together will be in different positions on the spindle.

It is perhaps hardly correct to say that each pair of coils is independent. It is so; but each two pairs are together in parellel arc at the brushes, and of course re-act on each other.

and from hand to head, both bare and moistened with brine in order to increase their conductivity, has been given variously at 500 to 6,000 ohms. Probably the resistance of a working man whose hands were hard and dry and well covered with dirt might be near the latter figure, if not higher. Now the current that the human body can stand continuously is very small indeed. In cases where it is applied to electrotyse a cancer, from $\frac{3}{1000}$ to $\frac{5}{1000}$ ampère is used, and $\frac{1}{60}$ ampère is considered a large dose, sufficient to waken the nerves of a paralytic if applied often enough. A healthy man could stand $\frac{1}{20}$ ampère for a very short interval, say the time occupied by a shock, supposing a wire to have been accidentally touched. The writer believes he has frequently taken as much, and at present feels no worse for it. These figures represent a current of $\frac{1}{20}$ ampère, a resistance of 6,000 ohms, and an electro-motive force of 300 volts, which may be taken as a good working limit, and, with care, may even be increased to 400 or 500 volts. But take a Brush machine for 40 lights, which has an electro-motive force between terminals of 2,000 volts, then from $\frac{1}{3}$ to 4 ampères for the resistance of the body is obtained, according as its conductivity is taken at 500 or 6,000 ohms.

Now, remembering that in these cases the effect, where the resistance is constant, varies as the square of the electro-motive force or the square of the current strength, it will be seen how serious the case becomes. It is quite possible to use high tensions where, as in the transmission of power, something is to be gained by it, provided proper precautions are taken; for instance that it shall be impossible, or at least very difficult for anyone to place himself, his body between his two hands, or from his hands to his feet, or any other portion of his body in such a position that the difference of tension between any two points shall be dangerous; and that all parts of the apparatus shall be very carefully insulated from each other and from the ground. Danger exists in taking hold with the two hands of two points of the circuit, such as two naked wires near the machine between which the electro-motive force exists, Fig. 6; or on a wet night with clothes, boots, and hands wet, standing on a wet ladder, or on wet ground, touching with one hand a point in the circuit whose electro-motive force is considerably above that of the ground on which one is standing. A further extension of the danger, especially in the last mentioned case, is, that every alteration of the current strength of any magnitude within itself gives rise to what is known as an *extra current* in the circuit itself, and in all branches connected with it. It is an induced current of momentary duration, but of very high tension. A man on a ladder, Fig. 7, in the position

described, forms a branch to the circuit, of high resistance; since the machine itself, for its enormous tensions, is never perfectly insulated from the earth.

The case of a man taking hold of two points in the wires that have a great difference of tension, such as he might do when up a pole repairing, is further aggravated by the fact that the muscles of his wrist are immediately contracted, so that his hands close tightly on the wires, and the current pouring through him *may* literally burn him to a cinder. It is stated that many men, especially in the United States, owe their lives when in this predicament to a friendly knock-down blow administered by a fellow workman. In the case of a sudden shock from the extra current, if death does ensue it is probably owing to stoppage of the heart's action.

The writer is pleased to note that deaths and accidents from this cause have apparently ceased during the last two years, presumably owing to greater care being taken.*

The ELPHINSTONE-VINCENT machine, Figs. 1, 2, 3, Plate V., is the only one of the direct current machines remaining to be described. It marks, in the writer's opinion, a distinct advance in dynamos. In this machine the armature consists of a hollow cylinder of non-conducting material such as papier-maché, on which are laid the coils of wire in parallelograms; the ends being brought to a commutator in the same way as in a Gramme. The cylinder revolves between opposite poles of two sets of electro-magnets; placed one set on the outside and the other on the inside, facing each other. The early machines had six brushes, or one to every pair of electro-magnets; the later ones have only one pair. The immense advantage is gained in this, of there being no conductor revolving in the magnetic-field except that which is furnishing useful current, and of there being no waste of energy in heating the core due to changes of magnetism. The writer knows of no continuous practical trial of the machine at present.

ALTERNATING-CURRENT machines are constructed on exactly the same principles as those with a direct current, except that there is no commutator to arrange the current all in one direction; the currents are allowed to find their way directly into the circuit just as they are generated, and are therefore reversed after passing each pair of poles; it is even an object to secure as many reversals as possible, and they are usually made with a number of smaller magnets or electro-magnets in place of two, four, or six large electro-magnets.

* Quite recently again, several cases have occurred, one at Lord Salisbury's and one even in the Health Exhibition.

The old ALLIANCE machine is described in all the text books and is out of date.

In the DE MERITENS machine, Fig. 4, an improvement on the Alliance, a circular frame carries a series of coils on the outside of its periphery, very much after the style of the Pacinotti ring, which revolve inside a ring of compound permanent magnets. In the larger machines several of these rings are built together parallel to each other. The coils generate currents as they pass in front of the poles of the magnets.

In the GRAMME alternating current machine, Fig. 5, a hollow cylinder contains a series of electro-magnets extending radially inwards, and faced by a similar series arranged like spokes of a wheel, and revolving on an axle; the revolving coils in this case are the field-magnets. The current is taken off by collars rubbing against each other.

In the SIEMENS alternating-current machine, Fig. 6, two vertical rings containing small electro-magnets face one another, unlike poles being opposed, with a small space between them for the armature to work in. The armature consists of a third series of electro-magnets, but without iron cores, the coils being wound on wood, adopting here the same principle that has been explained to be so efficacious in the Elphinstone-Vincent machine. The Siemens alternating-current machine is the earlier invention.

In the FERRANTI-THOMPSON machine, Fig. 1, Plate VI., which, so far as the writer is aware, is only constructed for alternating currents,* the same arrangement of field-magnets is made as in the Siemens alternating-current machine, but the armature consists of a single strip of copper wound round pegs on a disc of wood, as shown in Fig. 7, Plate V. The armature is suspended vertically and revolves at a high speed between pairs of electro-magnets as in the Siemens. The great advantages of the machine are the extreme lightness of the revolving armature and the simplicity of its construction. As at present constructed, it has usually to run at a high speed.

Having given a description of the construction of the different dynamo and magneto-electric generators now in use, the writer will proceed to describe dynamos generally and their uses. He would, however, first remark that though he believes the Gramme machine to be the best, perhaps because he has had most experience with it, yet the vital question now is, not so much the kind of dynamo itself, but the excellence of its workmanship.

* The writer understands that the Ferranti machine has been considerably modified and adapted for continuous currents since the above was written.

Provided the laws detailed above have been observed, that machine is best that is simplest, strongest, least liable to get out of order, and that gives the best return both commercially and electrically for a given expenditure of mechanical power. Given two machines equal in other respects, or nearly so, the preference should undoubtedly be given to the simpler and stronger, rather than that which gives the highest return.

The terms "electrical and commercial efficiency" require explanation. Electrical efficiency means that percentage of the mechanical energy delivered to the pulley of the generator, that appears as electrical energy in the whole of the electric circuit, including the currents passing in the wires of the generator itself. Commercial efficiency is that percentage of the mechanical energy delivered to the pulley of the generator, that is available for useful work in the external circuit. The mechanical energy in this case must not be confounded with the indicated horse-power in the cylinder of the steam engine. It is that, less the power absorbed by the engine belt, etc. The electrical efficiency will depend entirely on the construction of the dynamo; that is to say, it will depend on what power is lost in friction of bearings, in the mechanical action of turning the armatures, irrespective of the current furnished, or even when no current is furnished, and what is lost in the heating of iron cores through induced currents and changes of magnetism. To obtain the commercial efficiency, in addition to the figures subtracted for electrical efficiency, allowance must be made for the work done in the wires of the dynamo itself calculated from the formula $C_2 R = W$, as described.

By the aid of the above figures, as will be shown later on, working backwards, a calculation can be made as to the power required to furnish any particular installation.

It must be premised that the furnishing and keeping up the magnetic field represents a certain amount of work to be done, which is, in all but those machines where permanent magnets are used, a permanent charge upon the energy transmitted to the machine.* It has now to be considered how the magnetism of the electro-magnets that produce the magnetic field may be best maintained. It may be done either by using permanent or electro-magnets.

1. By Permanent Magnets.—This is, undoubtedly, the most economical, but is subject to two great drawbacks. The same amount of

* It is stated in the text books that, when once the iron core of an electro-magnet is magnetized, it requires no further expenditure of energy to maintain its magnetism, but as it requires an expenditure of energy to maintain the current passing in the magnetizing wires, it amounts to about the same thing.

work cannot be obtained from a machine of a certain size and weight as where electro-magnets are used, and the permanent magnets gradually lose their magnetism, so that the machine gives out less and less work, unless the magnets are periodically re-charged.

2. By Electro-Magnets.—It will be remembered that the electro-motive force developed by a conductor passing through the magnetic field in any given type of machine depends on two things: the strength of the field and the speed rotation, supposing the lines of force to be cut at the proper angle.

The strength of the field depends evidently, in any particular machine, on the strength of the magnets controlling it, and these, if they are electro-magnets, will depend on the strength of the current passing round them, for a given number of turns. As it is of great importance that the strength of the field should remain constant, it is also of great importance that the magnetizing current should remain constant, since with a given speed, the greater the strength of the current, providing the iron has not reached its point of saturation, the greater the strength of the magnets and *vice versâ*.

These may be charged or receive their magnetizing current in four different ways.

First, by a current from a separate dynamo machine run specially for this work ; one such "excitor" as it is called, furnishing the current for several machines. This method has the great advantage that the magnetic field, so far as the influence of the field magnets go, is independent of all changes in the circuit where the work is being done. It has the disadvantage that a second machine, with belts, straps, &c., is required; a very grave one for small installations.

Some few years back, before the incandescent lamp was produced, and when arc lights were not so reliable as they are now, it was of great importance that the magnetizing circuit should be independent of the lighting circuit, and so great were the variations in the working current, that this method was very generally adopted.

With alternating-current machines, it is absolutely necessary to have an excitor, as the reverse currents furnish little or no magnetism. With these machines, the dynamo and excitor are now usually mounted on one frame, their two armatures running on one spindle; the excitor being constructed just to do the work required at the speed of the generator. Fig. 2, Plate VI.

The next plan is the series dynamo, in which the current furnished by the revolving armature passes round its own inducing electro-magnets,

furnishing thus its own magnetic field. Fig. 6, Plate I., shows this arrangement, which can only be made use of by having in the iron core of the field magnets, sufficient residual magnetism to start a feeble current in the armature. This feeble current passing round the wire on the field magnets increases their magnetism, thereby increasing the strength of the current in the revolving armature, which again re-acts upon the field magnets, and so on until the limiting current is reached that the conditions of the circuit will allow. In practice, the time required for the dynamo to come up to its full current is inappreciable. In this arrangement the wire on the electro-magnets forms part of the circuit, and is subject to all the variations that take place in that circuit. Thus, should from any cause the resistance of the circuit be increased, say by the switching in of an additional arc lamp, the strength of the current decreases, and unless the speed of the machine is increased, it will not only not furnish the same current as before, but it will not be able to maintain even the reduced current through the additional resistance, owing to the strength of the magnetic field being reduced. On the other hand, should the resistance of the external circuit be reduced, say by the cutting out of an arc lamp, the magnetizing current is increased, and if the speed remains constant, the result is a large increase of current through the circuit. The result of this is that, while this method forms the very simplest and best where a number of arc lamps are required all of one size, it is not so well adapted for working arc lights of different sizes, except in special cases, nor incandescent lamps. For the latter it is only suitable where all, or nearly all, the lamps are put in and out together, or where it is no inconvenience to alter the speed of the dynamo, and where a certain minimum number of lights can always be kept going. The result of turning out say half the lamps furnished by a series dynamo in one parallel, if the speed remained constant, would be to diminish the light given by the rest.

For the arc lamps now in use, however, the working of the series dynamo is simplicity itself. So long as the ampère meter (an instrument that will be explained hereafter) points to the current the machine is working at, and the lights are burning properly, all is right.

The next plan is the SHUNT DYNAMO, in which only a portion of the current generated in the revolving armature is utilized to furnish the magnetism of the electro-magnets, Fig. 3, Plate VI. The current is divided at the brushes between the external circuit and the wire on the electro-magnets, which is now of a very much finer gauge, properly calculated to take only a certain portion of the current. The working of

the shunt dynamo is the reverse of the series. Every alteration in the outer circuit is reflected inversely in the magnetizing shunt circuit, but not to so great a degree as with the direct current in the series wound machines. Hence these shunt wound machines have been largely used for incandescent lighting; on the initiative of Messrs. Siemens and the Edison Company, all the earlier Edison machines were shunt wound. They are now, however, rapidly giving place to the compound wound machines, Fig. 5, Plate VI. Though in the shunt dynamo the regulation is far better for incandescent lighting than with series wound machines it is very far from perfect. Every increase in the resistance of the external circuit gives rise, if the speed remains constant, to an increased electro-motive force, owing to the increased strength of the magnetic field; and with very large installations, the matter became so serious that Mr. Edison worked out and arranged with his dynamos an elaborate system of alarms, at each of which compensating resistances were to be inserted or taken out of the magnetizing circuit.

The compound winding, attributed, it is stated, originally to Mr. Brush, but now generally adopted by all makers of dynamos, gets over the whole difficulty entirely, and with the most perfect simplicity. It is a combination of the two systems, series and shunt. Part of the field strength is due to the direct main current passing in a thick wire, and the rest to a loop of the current passing in a thin wire. The current divides at the brushes, as in the ordinary shunt wound machines, between main and shunt wires, only that now a certain length of thick wire on the magnets forms part of the external circuit, and only a portion of the available space on the electro-magnets receives the finer shunt wire. If the two branches are properly balanced, and the speed remains constant, almost any variation may take place in the external circuit within very large limits without affecting the electro-motive force at the terminals of the machine. As may be supposed, this arrangement is invaluable for incandescent lighting, especially in large installations where some of the lights may be at great distances from the generating station, and it is important that every consumer should be independent of his neighbour.*

A very beautiful modification of the compound winding has been arranged by Mr. Charles, the electrician to the late makers of the Gramme machine. By its aid it is possible to run a number of arc lights in series, and to turn them in or out without altering the speed. The object is

* Since the above was written, the writer has succeeded in running Brockie arc lamps and incandescent lamps from a compound wound Gramme machine, the variation due to the feeding of the arcs being imperceptible in the incandescents.

attained by so proportioning the magnetism due to the two circuits that the shunt is at its best when most required, namely, when all the lights are on, the series then doing very little; but as the lights are put out one by one, the shunt loses and the series gains, only the latter does not gain so much as the former loses; so that, though the speed remains constant where the external resistance lowers, the electro-motive force lowers also to meet it. It is obvious that the converse of this could be arranged. It must be noted, however, that in each and all of these the result is obtained only by careful experiment on individual machines, preceded by calculation.

The work that any machine will do is measured by the product of the current it will furnish into the electro-motive force between its terminals. The current it will furnish is limited by the size of the wire with which it is wound, and the current that can be safely allowed to pass through it without burning the covering. It should be noted that where there are different sized wires on a machine, the smallest, for its portion of the work, governs the strength of the current the machine will furnish. The electro-motive force between the terminals for any given size and type of machine is limited by the speed at which it can be safely driven, and the electro-motive force that is developed at that speed. If any dynamo could be driven at an unlimited speed without injuring itself mechanically, it would furnish an infinite amount of electrical work. With any given size and type of machine, running at a given speed, the electro-motive force depends directly on the number of turns of wire, or practically the size of the wire on the coil, presuming that the strength of the magnetic field is maintained constant.

The work that can be obtained in watts, that is current in ampères × electro-motive force in volts, from any machine of a given size and type, is practically constant; but it may be delivered in different forms, different current strengths and electro-motive forces, according to the size of wire of which it is constructed.

Take the two types of Gramme machine, A and B. The capacity of the A is roughly 2,000 watts; of the B, 5,000 watts. The A type may be had in the following different forms:—The old original A gives 20 ampères with an equal electro-motive force of 100 volts = 2,000 watts; the A_1 gives 40 ampères with 50 volts; the A_2 gives 12 ampères with 170 to 180 volts. These are actual machines that have been in the market for some time. In the early days of electric lighting, however, the A only was made, and it is only within the last two years that

sufficient advance has been made to modify the winding to meet different requirements. The A_1 is wound with a very thick wire on the armature, the A with a medium sized wire, the A_2 with a fine wire.

M. Marcel Deprez has constructed a machine of the A type, giving, the writer believes, about 2,000 volts and one ampère. The electro-magnets are wound with a gauge of wire corresponding with the current it has to carry, large with the A, and small with the A_2; the few turns with the thick wire on the A giving as much magnetism as the larger number of turns of thinner wire on the A_2.

The A_1 is intended to run 30 incandescent lamps in one parallel. The A, two powerful No. 1 arcs, as will be explained later on, or two parallels of 15 incandescent lamps each. The A_2 furnishes five smaller No. 2 arcs, or four parallels of incandescent lamps of eight each.

The writer sees no reason that it should stop there. He hopes to construct A_3 wound with still finer wire, giving a current of five to six ampères, and having an electro-motive force of 350 to 400 volts, furnishing ten still smaller arc lights. The B, which is a larger-sized machine, may be followed through the same changes.

The B gives	50	ampères	and	100	volts.
„ B_1 „	100	„		50	„
„ E „	25	„		200	„
„ H „	18	„		280	„
„ H_1 „	18	„		330	„

The H and the H_1 have the same gauge wire on the armature, but the H made to be excited by a separate machine, the magnets are wound with more than proportionately thick wire, consequently the electro-motive force is lower than in the H_1, in which the proper gauge of wire is used. The B and B_1 furnish 70 to 80 20-c.p. lamps each; the E, six arc lights, or four parallels of 17 incandescent lamps each; the H, eight arc lights, or five parallels of 14 incandescent lamps each; the H_1, ten arcs, or six parallels of 14 each.*

The writer has chosen the Gramme machine for illustration, because, as has been already explained, he is most familiar with that type, having been connected with it almost since its first introduction into England; but the same remarks apply to every type of machine, unless where structural difficulties intervene.

The Brush machine, apparently, does not lend itself readily to low tension winding; but the writer is not aware of any other case.

* These figures are subject to modification, with the advance of the manufacture.

ELECTRIC LAMPS.

Having obtained an electric current, the next requirement is an apparatus to convert it into light.

This apparatus is termed under whatever principle it works, an electric lamp. Electric lamps are at present only of two kinds, arc lamps and incandescent lamps; the semi-incandescent lamp having gone quite out. The arc lamp takes its name from the arc or bridge, which is formed between the ends of the two carbon rods, when light is being given out. Carbon is consumed in this form of lamp, minute portions being vaporised at an exceedingly high temperature. The arrangement in all arc lamps is very similar; two carbon rods are held vertically, horizontally, or at an angle, in such a manner that they can be fed towards each other as they consume. The distance between their ends remaining, as nearly as possible, constant. The mechanism employed in attaining this object, forms the subject of the numerous patents that exist for arc lamps. Owing to various causes, it was for a long time by no means easy to ensure that the distance between the carbon ends, or the length of the arc, as it is called, should be always the same. In the earlier lamps, in fact, it very rarely was so, and the perfection of regulation in those days appeared to be to have the whole apparatus, engine, dynamo, and lamps, so arranged that they would respond to calls from each other. Thus, when the arc increased in size, the engine would run faster, and *vice versâ*. In those days, only one lamp could be fed by one machine, and to get the best results, two machines were required. Now a different principle is adopted. Every effort is made to keep the speed of the dynamo constant, and the size of the arc the same.

ARC lamps may be divided, roughly, into clock-work lamps, clutch lamps, candles, and purely electrical lamps. Both the clock-work and clutch lamps have also two subdivisions.

(*a*) Those in which the carbons are at first placed together and then separated by the action of the current.

(*b*) Those in which the carbons are normally separated, and are allowed to run together when the current starts.

Both the clock-work and clutch lamps are similar in several particulars. Both consist usually of a light framework, Figs. 2, 4, and 5, Plate VII., in which the carbons are held, generally one above the other, surmounted by some form of case, in which is contained the electro-mechanical arrangements for making the arc, or running the carbons together, as the case may be, and for feeding them onwards as they burn away. In the clock-work lamps, the upper carbon holder is usually connected to a rack, which

gears into a train of wheels. The carbon holder can only descend when the wheels are free to revolve. A brake is applied to the last wheel of the train, and the train itself is controlled by an electro-magnet, fed by a shunt wire across the arc. Fig. 1, Plate VII.

In those lamps in which the carbons are together at the start, there is an electro-magnet, constructed with thick wire, included in the main circuit with the other lamps, and it is usually arranged to lift the frame-work in which the rack and wheels are held bodily, at the same time locking the brake. There is usually a regulating arrangement attached to the brake, by means of which its tension may be altered, according to the size of the arc required. The shunt-magnet, before referred to, which is fed by a wire looped across the positive and negative terminals of the lamp, is arranged to release the brake when the arc attains the size to which it is set. The result is, that as soon as the arc attains this size, the brake is released, the wheels of the train are allowed to revolve, the upper carbon holder descends, and the arc shortens. As soon as the arc attains a certain size, the shunt electro-magnet again loses its power over the brake, which again becomes locked, till the arc again burns beyond its limits, and so on.

The successful working of this lamp depends on the sensitiveness of the brake and shunt-magnet. If the shunt-magnet is sluggish in acting, the arc gets too large, and then too often the carbons run down nearly into contact; the result being very large changes in the volume of the light given out and in the strength of the working current. In a well regulated lamp the armature of the shunt-magnet is hardly ever still, now locking the brake and then releasing it.

In those lamps in which the carbons are apart when the lamp is not burning, there is no main electro-magnet. A strong spring, whose tension can be regulated, keeps the carbons normally separated. On a current passing through the shunt electro-magnet, the carbons are allowed to run together, and as this deprives the shunt-magnet of its current, the brake is at once applied, and the spring before referred to separates the carbons, as did the electro-magnet in the other form. The feeding is accomplished exactly as in the lamp previously described. When the size of the arc reaches a certain fixed limit, the shunt-magnet releases the brake, allows a feed, and so on.

This form has the advantage of being slightly simpler in construction; but it has the grave disadvantage that, owing to the carbons being apart when the machine is started and there being only the path through the very high resistance shunt electro-magnet, it is necessary to use one of

those forms of machine in which the excitation of the electro-magnet of the dynamo is independent of the resistance of the external circuit. The simple series dynamo cannot be used without special apparatus.

Fig. 1, Plate VII., shows a Crompton clockwork lamp of the old form, in which there is no electro-magnet in the shunt circuit, the brake being controlled by the spiral spring, *a*, and small vibrating armature, *b*, shown. In this lamp the lower carbon holder is pulled down to form the arc, by the main electro-magnet *m* attracting the main armature A. Above the main armature a small steel plate, *b*, is pivoted, forming a second armature. This last being very light and easily moved is more readily acted on by small changes of current in the main electro-magnet than the large armature. The small armature, *b*, actuates the brake, *c*, which works on the last of the train of wheels, and its position is the result of the opposing forces, the magnetism of *m* pulling down, and the tension of the spring pulling up. As the tension of the spring can be regulated by the screw *d*, the lamp can be made to work very well by itself, that is, when run from a circuit of wires, quite independent of any other lamps, and the writer has also succeeded in getting it to work very well indeed in derived circuit with other lamps of its own pattern; but for series working, and even when running alone, with a machine to furnish the current for each lamp, it develops one exceedingly troublesome fault. If the magnetism of the large electro-magnet, A, falls from any cause, or, what amounts to the same thing, if the strength of the working current falls, the difference in the pull on the light steel armature may be sufficient to release the brake and allow the carbons to run together, without the main magnet letting go its armature. The result is that the carbons are locked together and the light goes out, only giving that which arises from the glowing carbon, until they either burn themselves clear and again form their arc, or the circuit is broken and the upper carbon forced back sufficiently against the train to allow the lower carbon sufficient clearance to form its arc once more. In practice this may occur from two or three causes. The engine losing speed, or the belt slipping, if in derived circuit with other lights, one or more of the others making a large feed, thereby lowering its resistance and taking more than its share of the current; if in series, one or more of the other lights burning long arcs and thereby weakening the total current strength.

In some of the later lamps the small steel plate pivoted over the main armature was abandoned for a detached armature controlled by an electro-magnet fed by a shunt across the arc, the brake itself being kept down by a lever actuated by a spiral spring. The brake, in this form, is thus

always locked, except when, by the arc reaching a certain size, the shunt magnet acquires sufficient power to pull it off. The size to which the arc burns in this case is regulated by the tension of the spring actuating the brake. The greater the tension the larger the arc must become before the shunt magnet acquires sufficient power to overcome it.

Mr. Brockie has also worked out a clockwork lamp, very similar in principle to the Crompton lamp just described, but with many of its parts simplified. As Mr. Brockie uses the solenoid form of electro-magnet, both for his main and shunt magnets, he obtains, in the writer's opinion, a simpler and at the same time a more sensitive feed motion.

Crompton appears to have abandoned these lamps for what he calls his double differential, which is shown in Fig. 2, Plate VII. He claims that this is not a clockwork lamp, and he has, in fact, dispensed with a large portion of the wheels, though he still uses a rack. Only one electro-magnet is used, half being magnetized by a thick wire in the main circuit and tending to separate the carbons, and the other half by a thin wire in the shunt circuit, tending to release the brake and allow the upper carbon to fall.

It is a remarkable fact that, whereas all the earlier lamps used clock-work and were discarded, being so painfully difficult to regulate, now after passing through various stages of lamps far simpler in construction, the best lamps in the market are, with a few exceptions, clock-work lamps. The writer fears, however, that even the very best clock-work lamps would fail at a colliery.

The successful working of these lamps depends, as does the successful working of clocks and watches, entirely upon the wheels being free to move quickly when they are required, and upon their moving only so much in each interval as is required.

Suppose a clock-work lamp to be hung over the screens at a colliery. Without the slightest doubt coal dust would penetrate between the wheels of the train, with the result that it would gradually refuse to feed when required; consequently the arcs would gradually get larger and larger, and would then probably either go out altogether, or go in and out at irregular and uncertain intervals. Probably they would start all right and burn for a short time, giving their proper light; gradually the arc would get larger and bluer, and finally it would go out, till from some cause, such as the jerking of the framework, the carbons ran together again.

The SIEMENS PENDULUM lamps, Fig. 3, Plate VII., though not strictly clock-work lamps, in the sense that they have no train of wheels,

partake very much of the nature and troubles incident to those lamps. Their action depends on the revolution of a pinion, gearing into a rack, which forms the upper carbon holder and which is controlled by a pendulum. When the pendulum oscillates the wheel turns, allowing the rack to lower, bringing the carbons closer together; but the pendulum, when once the arc is formed, is locked by the following arrangement. The rack, pinion, and pendulum, are held by an oblong frame which is free to move vertically and which is raised by the action of an electro-magnet in the main circuit. As soon as the frame reaches a certain distance from its state of rest, a small tongue attached to the frame catches in a recess in the body of the lamp itself and locks the whole thing. So long as the tongue remains in the recess the upper carbon cannot descend, no matter how large the arc may be. The electro-magnet, which is usually of the solenoid form, is opposed by a spring, the tension of which regulates the size of the arc. It is also arranged in some forms to compress a reservoir of air in falling, that the arc may not change too suddenly.

The lamp shown in the drawing is a later one, an improvement in the points of simplicity and strength. *m* is the solenoid electro-magnet, *c* is the core which is sucked into the centre of *m*, in proportion to the strength of the current; *l l* is a lever, pivoted at *v*, which transmits the downward motion of the core *c*, to the frame *f*, which, with its wheels and rack, rises vertically, forming the arc. The brass sector *a*, is arranged to oscillate with the pendulum *p*, and to this sector is attached another pendulum *q*, whose office is to lock the frame when it has formed its arc. This it does by slipping under a pile on the lever *l l*.

When the strength of the current falls below a certain figure, the core *c* rises and releases *q*, which again allows the sector *a* and pendulum *p* to vibrate. While *p* is oscillating, the rack is enabled to move the train of wheels and move down, thereby shortening the arc. This again restoring the strength of the current, causes *c* to lower, *f* to rise, and *q* to lock the whole as before.

In the simple pendulum lamp, the size of the arc and the strength of the current may vary very much, so long as the engine will follow; increasing speed when the arc increases, and *vice versâ*. It is obvious that for working several lamps in one circuit, the changes in the strength of the current would be too great, so that this form is only used to produce one very large light from one dynamo.

Where more than one lamp is required from one machine the differential pendulum lamp is used. The construction of this lamp is precisely

the same as in the simple lamp, except that a second electro-magnet, usually on the solenoid principle and fed by a shunt wire across the arc, is employed to pull the frame down and release the pendulum as soon as the arc reaches a certain size.

Neither of these lamps, which it is only fair to say work remarkably well in places for which they are suited, are, in the writer's opinion, adapted for collieries, for the simple reason that should any of the parts get clogged by coal dust and act sluggishly, the lamp must feed badly, causing flickering, extinction, and so on.

In the CLUTCH lamps the clockwork is replaced by some form of clutch, so arranged that, when no current is passing, the top carbon holder, usually a tube sliding vertically through the lamp, is free to move up and down. On the current passing, an electro-magnet in the main circuit generally (there are a few notable exceptions) actuates the clutch, causing it first to grip and then to raise the upper carbon rod to the distance necessary to form the arc. The feeding is accomplished in various ways.

In the BRUSH and WESTON lamps the same electro-magnet which actuates the clutch carries on it a loop or shunt wire similar to that in the clockwork lamps, wound so that the magnetising effect of this wire is the reverse of that produced by the thick wire in which the main current is passing. The result is that so long as the arc is small, the magnetism due to the shunt wire is very feeble and has no effect on the main; as the arc increases, however, the shunt gradually acquires strength, and at uncertain intervals the clutch is partially released, allowing the carbon holder to slide through. In the Brush and Weston the clutch is simply a brass washer. Fig. 4, Plate VII., shows the Brush lamp, and as it has acquired a certain celebrity, it may not, perhaps, be amiss to describe it more particularly.

In the BRUSH lamp as now made there are invariably two pairs of carbons. The lower are held in sockets, *a a*, on a circular base, supported by the framework of the lamp; the upper are held in sockets attached to tubes, *b b*, which slide vertically through holes in the frame of the box in which the regulating apparatus is contained, and inside larger tubes, *c c*, rising from the box. The tubes, *b b*, are filled with glycerine and water, a small piston, *d*, works inside, suspended by a wire from the top of the box, the result being that, although the washer forming the clutch may be quite loose, and the electro-magnet frequently has very little hold on it, the carbon holder is by no means free to slide up and down. Its motion is very slow when no current is passing, so that the regulation of the lamp is almost independent of the electrical conditions;

or, perhaps, it would be more correct to say that the condition of the electrical circuit determines whether the carbons shall be free to slide downwards as fast as the glycerine inside the tubes will allow them. The descent of the tubes is further resisted by a pair of small wire brushes pressing on them, whose pressure can be adjusted as required, and by a small brass vessel holding glycerine, in which works a piston attached to the armature.

The electro-magnet in the Brush lamp is of the solenoid form, that is to say, the wire is wound on tubes, and inside these tubes slide rods of iron, which are sucked up or allowed to fall according as the magnetic effect increases or decreases. The armature, *ff*, formed of the two cores, with a connecting piece, actuates the lifting arrangement shown in Fig. 4, Plate VII., which, when the armature rises, first tilts the washers on each carbon so as to form a grip, and then raises them till the lifting power of the magnet is balanced by the weight opposed to it. The lifting arrangement shown at Fig. 4 is so arranged that it lifts one carbon first, and then the arc forms between the other pair. The pair which burn first are supposed to burn completely out before the others start. In practice, however, this very rarely happens; frequently one carbon sticks and the lamp goes out, until the other one falls down and makes its arc. There is no provision in this lamp, as there is in most later lamps, for regulating the size of the arc at will. In the Brush lamp the size of the arc is dependent upon several points, over which the user has frequently no control. The viscosity of the glycerine, both in the carbon holders and the regulating cylinder, but especially in the former, very seriously affects the working of the lamp, quite irrespective of the electrical conditions. If the glycerine be too thick, supposing everything else to be working properly, the lamp will feed more slowly than it ought, its arc will increase, the light will become blue, and it will finally go out, or nearly so, for a short time. On the other hand if the glycerine be too thin the lamp may feed too quickly, and so drop into contact. Each lamp in the circuit is also affected very much by what the other lamps are doing as well as by its own behaviour; so much so, indeed, that one faulty lamp, one that feeds either too slowly or too quickly, may cause all the others to burn badly.

Suppose a circuit of sixteen lamps to be started, all with small arcs, the engine at proper speed. All the arcs increase in burning, and, unless either the feed of the lamp is very fine indeed, or the engine follows readily accommodating its speed to the resistance of the circuit, or both combine to keep the current strength constant, the latter will in a

short time be very much reduced; consequently, the lifting power of the magnets is reduced by the two factors, the increased reverse action of the shunt coils and the decreased strength of the main current.

Under the best conditions, when the lamps are clean, the glycerine exactly of the right viscosity, and everything perfectly adjusted, the armature is continually moving up and down, allowing the carbon holders to slide down by a succession of minute slips.

The very best working that the writer has ever seen with Brush lamps consists of a succession of small slips, each slip making a flicker. Suppose that one or two of the lamps, as may easily happen, are not in perfect working order, and that two, feeding slower than they should, make long arcs; the current strengtn decreases still farther for a time, till the faulty lamps are automatically cut out, in a way which will be explained presently. This will produce an equally sudden and sometimes a very great increase of the current strength, and cause the feed of the rest to be temporarily suspended; then those lamps that happen to be in a favourable position make long arcs, and produce continual changes in the volume of the light given out by each lamp; on the other hand, the current may be so weakened that there is not sufficient magnetism in some of the electro-magnets to hold up their carbons, which consequently fall, and the light goes out. At one minute there is a good white light, at the next a blue light, and the next none at all. Unless the engine is very perfectly governed, too, it follows the variations of the circuit, *after* they have taken place, so that the irregularity is increased.

The automatic cut-out attached to the Brush lamp is certainly the part to which whatever success the Brush lamp has attained is most due. It consists of another small electro-magnet, fed by a wire forming part of the shunt coil of the electro-magnets that work the upper carbon. It is faced by a light armature, whose end, tipped with copper, is opposite another copper pole, which is so arranged that when the arc attains a certain size, the armature, being attracted, completes the circuit between the terminals of the lamp without passing through the coils at all; the current passing on to the next lamp, and thus avoiding the danger of putting the whole of the lamps out by breaking the circuit.

Another feature in the Brush lamp that no doubt helped to such success as it attained, was the complete manner in which it was sent out. Every care was taken so that the lamp, globe, hood above, sliding screen, &c., should be perfect and the light protected from all weathers.

In the WESTON arc lamp an ordinary electro-magnet with solid cores is used, the shunt coil being wound in a special manner, presumably to increase the sensitiveness. It has no glycerine in the carbon holder, though it has the glycerine dash-pot attached to the armature, as in the Brush.

On the other hand, the arrangement of the double-carbon lamp is not so simple as the Brush, the carbon not in use being locked until the other is quite burnt out, and having a special electro-magnetic arrangement to release it. This lamp is open to all the faults of the Brush in the matter of unsteadiness, but in a minor degree.

In any circuit of either Weston or Brush lamps, it will rarely be found that two lamps burn alike, or that any one lamp will give the same light for any length of time. The reason is, in the writer's opinion, that the whole thing is so entirely out of the engineer's control—except in so far as he can guard against possible failure by careful attention—that he has not that command of the apparatus that he should have, and that he has in other lamps.

The BROCKIE commutating lamp, Fig. 5, Plate VII., is the one that the writer believes to be for collieries, and other large works, by far the best that can be used. It is, for out-door work, the steadiest, the simplest, and most easily managed.

There is the same framework as in the Brush and Weston, surmounted by a box holding the electro-magnet and regulating arrangement. The top carbon holder slides through this box as usual, through a clutch, Figs. 1 and 2, Plate VIII., consisting of a short hollow cylinder, *a*, through which the carbon holder passes.

At the top, *b*, one half the cylinder is cut away, its place being taken by a hinged brass leaf, *c*, supporting a small steel plate, *d*, in which a semi-circular space has been filed; this space faces the opposite half of the cylinder, forming with it the washer used in the Brush and Weston. When the leaf is down, the rod can move quite freely up and down. When the leaf is raised it grips the upper carbon holder, and then the whole clutch and upper carbon rise vertically together, forming the arc. Above the clutch is the electro-magnet which works it, and to whose armature, *f*, the leaf of the clutch, in the single lamp, is rigidly attached. Below the clutch is a screwed tube and locking collar, *g*, screwing into the bottom of the box; the upper carbon holder also passes through this tube, whose office is to regulate the size of the arc. As the distance through which the armature can rise is fixed, the higher the point at which the clutch commences to rise, the smaller the arc, and *vice versâ*.

The electro-magnet is fed by a separate wire direct from the machine, and forming a shunt to the main current. This current is broken at short intervals of time, for an instant, by a commutating arrangement fixed in the engine house, to be presently described.*

The action of the lamps then is as follows:—When the current passes, the top carbon holder is picked up, forming the arc. Before it has time to alter its resistance much, the commutator in the engine-house breaks the current, the top carbon holder is released, the top carbon drops upon, or nearly upon, the bottom one, and is instantly re-set to its original arc. The result is that a flicker is produced which is hardly perceptible in the open air, and behind ground glass or opal is absolutely imperceptible.

The commutator is shown in Fig. 3, Plate VIII. It consists of a brass box containing a toothed wheel, *a*, revolving on a spindle in the centre. The wheel is caused to revolve by means of a pulley, *c*, driven by a small strap from any convenient source of power, such as the spindle of the dynamo, the axle of the engine, etc.; which is attached to a worm, *d*, gearing into the toothed wheel. The wheel has also an eccentric pin, *f*, on its upper face. Round the box are pivoted small pauls, *h*, which press against the spindle of the centre wheel and are kept pressing against it by strong springs. The pauls are insulated from the body of the box and from each other. A wire is taken from the positive side of the machine direct to the box. The current delivered by this wire is distributed between the pauls, and by them and wires connected to terminals attached to them, to the lamps they have to feed. As the wheel revolves, the eccentric pin comes to each paul in succession, pushes it away from the spindle against which it was pressing, still, however, maintaining the current unbroken, and then later, as it slips out from beneath the paul, allowing the latter to fly back to the spindle in the centre. During the short interval occupied by the paul in flying back to the spindle, the current

* Brockie Lamp.—The writer has succeeded in dispensing with the separate branch wire for feeding the electro-magnet, in the case where the lamps are run in parallel arc, each lamp taking its current direct from the machine. In a small installation, consisting of two arc lamps and 20 incandescent lamps that he has recently fixed for the Powell Duffryn Co., at their new George Pit, each arc lamp, and each group of incandescent lamps, takes its current direct from the machine. The wire forming the coils of the electro-magnet controlling the feed forms part of the same circuit with the carbons, there being no separate wire for it. So far, the lamps burn remarkably well, and there is no difficulty about the feed. In fact, the writer has had them burning without the commutator, the lamp taking its feed merely by the weakening action of its own arc upon the holding power of its own electro-magnet. He is hardly prepared, however, to dispense with the commutator, as a rule, at present.

passing to that lamp or set of lamps is broken; with the result that the upper carbon holder is released for an instant, during which the lamp is re-set.*

There is also a very ingenious double-carbon lamp by Mr. Brockie, Fig. 7, Plate VIII., on much the same principle as the double-carbon Brush, namely, one carbon is picked up before the other, and is held clear until the other burns out.

It would be difficult to imagine a simpler lamp, and one so well adapted for colliery work, as the single Brockie lamp. One great advantage it possesses, too, is that it can be worked with any machine without being specially constructed for it. With nearly every other lamp it is necessary that the electro-magnets of the lamp should be wound in accordance with the current it is desired to work with. Should the wire be large, for instance, the magnetic power is not obtained with a small current; and should it be small, it can only carry a limited current, otherwise the wire would heat and destroy the insulation. With the Brockie lamp this difficulty is avoided. No matter what wire the lamp is wound with, within certain large limits, nor what current the machine will furnish, one can always be worked with the other with the aid of a piece of iron wire, as shown in Fig. 8, Plate VIII.

The writer has had these lamps working over coaling screens and in the hands of colliery officials for several years, without the slightest hitch. He has seen a lamp with half an inch of coal dust in the box working fairly well, and does not know of any other lamp that would work under similar conditions.

The LEVER lamp is the only clutch lamp the writer knows in which the carbons are apart when at rest. Fig. 9, Plate VIII., shows the lamp. There is the usual framework and box surmounting, through which the carbon holder passes. The clutch, which is in the form of a thick washer, fitting rather closely to the tube, forming the upper carbon holder, is held in such a position by a strong spiral spring placed for the purpose, that the upper carbon is raised from the lower to the distance required to form

* The writer's firm have introduced a new form of commutator, which is shown in Figs. 5 and 6, Plate VIII. It is a brass drum, against which press springs *b b*. The drum takes the place of the toothed wheel in the original commutator, receiving the current for the feed wires direct from the machine, and distributing it between the springs, from wires connected to the terminals *e e*, convey it to the different lamps. The drum is caused to revolve either by a strap from any convenient source of power, or in any other manner. On the face of the drum are small intervals of insulating material, *c c*, with which the springs come into contact in succession, breaking the feed circuit for the small interval during which the spring is passing over the insulated gap.

the arc. The only electro-magnet in the lamp is fed by a shunt across the arc, and is so arranged that when the arc reaches a certain size it pulls down the clutch, slightly releasing the upper carbon holder and allowing it to fall.

The lamp is simple, but has two grave faults. The fact, already pointed out in connection with another lamp, that a special form of machine is required to work with it, and the great uncertainty of the feed. Now the lamp burns a long arc before feeding, and then, perhaps, makes a big feed, greatly reducing the light; and again, it may only burn a small arc before feeding. Apparently, too, there seems to be no means of regulating the feed. The writer also objects, as being wrong in principle, to the spring always being in a state of tension, both when in or out of use.

The only other lamp in this series that the writer proposes to describe is the MOTOR, Fig. 11, Plate X., which has been worked out by the firm with which he is connected. After carefully watching the working of the Brush and the other lamps, and carefully studying the Brockie, it seemed that the unsteadiness so noticeable in most arc lamps was due principally to two causes; the feeding taking place at too long intervals of time, and the increment of feed being too large. In the Motor lamp he believes these two defects have been quite overcome. The lamp has not yet been placed in the market, and is not to be recommended for collieries, except in special places; but for indoor work, to illuminate large open rooms, where now, owing to the flickering of the lamps, it would be necessary to have a number of arc lamps, it will be found exceedingly well adapted, especially since it lends itself readily to subdivision. Its construction is very similar, in many points, to others. There is the usual framework with the box surmounting it. The regulating arrangement consists of a lever *a*, supporting in its centre a clutch *b* similar to that which has been described in the Brockie lamp. The clutch is actuated by an electro-magnet *m* in the main circuit, which attracts an armature *a* attached to one end of the lever. The other end is supported by a spiral spring, whose tension can be adjusted. Over that end of the lever is a disc *c* having a swelling or projection at one or more points in its circumference. The disc revolves in contact with the end of the lever, being actuated by a small worm and wheel, revolved by an electro-motor *e*. The electro-motor is fed by a shunt current across the arc, and is so arranged that it only receives sufficient current to drive the wheel when the arc is at a certain size, and from that point the larger the arc the faster the motor goes, and *vice versâ*. As the disc

revolves, each time that a projection comes to the lever it depresses that end, and with it the clutch, causing a very minute slip of the carbon holder. The feed is arranged as nearly as possible in exact proportion to the consumption for a given current, but slightly in excess, so that it constantly keeps up the supply to the proper limit. Should there be an increase of arc from any accidental cause the motor simply runs faster until it has reduced the arc to its proper size, going slower and slower as this is accomplished. Should also the current strength increase from any cause, as will occasionally happen, causing the carbons to burn away faster, the proportion of the increase received by the shunt will enable it, by running faster, to keep up the supply in accordance with the increased consumption. It will be seen that this lamp accomplishes another object in being more independent of what is going on in other lamps in the same circuit within very wide limits. So far as it has been tried, it burns absolutely without a flicker.

PURELY ELECTRICAL LAMPS.

The PILSEN lamp, Fig. 1, Plate IX., is one that stands quite by itself; there is no other like it. Inside the box, above the usual framework, are two solenoid electro-magnets, one over the other; one is in the main circuit and the other in the shunt. The upper carbon holder is connected to an iron rod made lighter at its ends than in the middle, and this slides freely through both solenoids, taking up a position dependent on the strength of the current in each. Thus, when the current first passes, the arc is formed by the upper carbon being raised, the main solenoid having the strongest pull. As the arc increases, the shunt solenoid gets a greater pull and lowers the carbon holder, which remains where it is placed. The lamp burns well when placed in a current suited to it, but the above simple construction has been complicated by the addition of automatic compensating resistances, and other delicate apparatus, that render it rather unsafe to be put into inexperienced hands. The great feature about the lamp, upon which the regulation depends, is the formation of the iron core, which renders it more sensitive to the varying pulls of main and shunt solenoids.

The GÜLCHER lamp, which was first constructed on the plan of the old Serrin, as described in the text books, viz., with an oblong box, from which rose the standards, one carrying the upper and the other the lower carbon holder, is now constructed with the usual hanging framework introduced by the Brush, the regulating apparatus being on the top. The

regulator is exceedingly novel. There is no clutch or clock-work of any kind. The upper carbon holder, or at least that portion which passes through the box, is of iron. Facing this is an electro-magnet pivoted on trunnions at the centre of its length, the electro-magnet being fed by the main current. On one side of one pole of the electro-magnet is a block of iron fixed to the frame of the lamp, and the position of this lump of iron is such that the electro-magnet being attracted towards it, and turning on its axis, its other end attracting the iron upper carbon holder, raises the latter a short distance from the lower, forming the arc. As the arc increases, the strength of the current decreases, and with it the strength of the magnet and its hold on the upper carbon holder, the result being that the latter falls until the magnet again acquires strength sufficient to hold it in its place. In order to facilitate the action of the lamp both poles are rounded, so that only a small surface is in contact, the two iron surfaces being further magnetically insulated by a thin covering of brass. As there would be great danger that the lamp would be irregular in action, making a longer and longer arc, and then perhaps dropping right into contact, the light going out altogether, a simple magnetic brake is added, consisting of a light spring with a piece of soft iron attached, like the contact breaker of an induction coil, which faces the opposite pole to that facing the carbon holder. The electro-magnet in moving has to overcome the friction of this brake in addition to that of the carbon holder, preventing a too sudden fall. In the writer's opinion, the danger of a long arc still remains; but as it was designed that several of these lamps should be run from one machine in derived circuit only, and kept at one speed, each lamp taking its current direct, and was, as in the Gülcher system, made independent of variations in the external circuit within very large limits, this danger was considerably lessened. Provided the electro-motive force at the terminals of the machine remained constant, as soon as the arc of any lamp attained a certain size, its electro-magnet would be sufficiently weakened to give a feed, and as it took its current direct from the machine it would not, provided the feed was not too long, seriously affect the other lamps in the circuit. In the writer's opinion, this lamp would not work well in series with a number on one circuit, but the writer understands that since the owners of the patent have abandoned the plan of constructing their dynamos to give one standard electro-motive force, and that a low one, the lamp has been modified so as to be able to run in series. If patents would allow it, some shunt arrangement to assist in releasing the armature would undoubtedly be beneficial.

The SUN lamp is a simple lamp working with an alternate current. The carbon rods in this lamp are fed onwards by the action of a spring or pulley, against a marble block which is itself gradually consumed as the lamp burns, and the light given is from the incandescent marble and from the incandescent carbon. The lamp *looks* remarkably simple, but appears not to have made much progress, for in practice, several additions, such as re-lighters, etc., seem to be required, which detract greatly from this desirable quality.

The only arc lights remaining to be described are those known as ELECTRIC CANDLES. They usually consist of two or more vertical and parallel sticks of carbon, the current forming an arc between their ends. Of these, at present, the only survivor appears to be the one originally invented by the late Mr. Werderman, and which is known as the Jablochkoff. This, too, in spite of a successful installation for several years on the Thames embankment in London, together with the support of a wealthy syndicate and great simplicity of arrangement, appears not to have made much way. In this well-known apparatus the carbon pencils are separated and held together by a thin strip of plaster of Paris. On the top of each pair is a small pellet of carbon forming the connection between the two carbons, without which the current could not pass. When the current is made it passes up one stick of carbon across the small pellett, vaporizing it in its passage, and down the other, the arc then forms between the ends. As the carbons burn down the insulating substance is also consumed, the light given out being from this cause of a more or less rosy tint.

It is absolutely necessary, so far as invention has gone at present, to work these electric candles with an alternating current; the reason being that, with the continuous current one carbon burns away twice as fast as the other, so that with a parallel arrangement, one would soon be longer than the other and the light would go out.

Several attempts were made to get over this difficulty, when the Jablochkoff candle first came out, by doubling or increasing the size of the positive carbon, and so on, but without success. In practice several candles are placed in one lamp, and as one burns down another is brought into circuit by the action of a simple automatic switch. The light is unfortunately by no means steady, principally owing to the insulating substance between the carbons, and it further labours under the disadvantage that the candles require more power than other arc lamps.

INCANDESCENT lamps are all constructed on one principle; the honour of first perfecting the practical application of which, the writer believes,

is due to Mr. Swan. Several electricians appear to have been working on the same lines as Mr. Swan, notably Mr. Edison and Mr. Maxim in America, and Mr. Lane-Fox and others in England. Practically the Swan is the only survivor of these, and through the Edison and Swan Companies having joined hands, it is difficult to know what one may have borrowed from the other. The Swan, however, was from the first, superior to any other; and the manufacturers further conducted their business upon sound commercial principles, for when each patentee of a dynamo constructed his machines so as only to give certain currents and certain electro-motive forces, and made his lamps or someone else's just to fit them, rendering it compulsory either to adopt the whole of his *system* or go elsewhere, the Swan Company made lamps to suit various requirements, and there was hardly a machine in the market that a Swan lamp could not be found to fit so as to give out its best results.

The SWAN lamp has been so frequently described in Newcastle and is so well known that it hardly requires repetition here. The hair-like filament in its globe, with the platinum wires passing through the hermetically sealed glass globe, connected on the inside to the ends of the filament, and looped outside for the reception of the holding hooks, is too well known in the north to need further description. A reference, however, to a very old experiment that has been shown by Mr. Swan for this very purpose, may help to make clear the principle on which it works. If a compound wire be formed consisting of alternate lengths of platinum and copper, and a sufficiently powerful electric current be allowed to pass through, it will be found that the copper will remain cool, while the platinum becomes red and even white hot. If a very fine stick of pure carbon is inserted in the circuit, this will become, provided it be of the same section, white hot, while the platinum remains cool. Naturally, such a ready method of producing light received the attention of the early experimenters, and it will be in the memory of the members that Mr. Swan himself had made some very important experiments in this direction twenty years before the production of the lamp which he has now made so successful. Unfortunately, in those days, no means were known of preserving the carbon from consuming under the action of the heat that was causing it to give light. It quickly oxidized and was destroyed, even with a weak current. The experiment was tried of enclosing the carbon in a vessel from which air had been excluded; but neither glass blowing nor air-pumps were so perfect then as they are now, consequently that attempt also failed.

The heating effect in any conductor is proportional to the square of the current multiplied by the resistance of the conductor; and the

resistance of a conductor of given section depends simply on its length; therefore, with a fine carbon filament and a current of sufficient strength to render it white hot, it is evident that as much light as is required can be obtained, provided there are some means of supporting a filament of sufficient length.

Two or three classes of the Swan lamps are made ranging from 2½ to 20 candle-power, in which the length of the filament determines the amount of light given out. Another of a thicker filament taking a larger current for 50 and 100 candle lamps; the length of the filament in this case also depending simply on the amount of light required. There is also a special form of 20 candle-power lamp in which the filament is made very thin for larger installations. Remembering again that the resistance of a conductor of a certain length varies inversely with its cross section, it will be easily understood that the thicker the filament the greater the current required with a given length for a given amount of light. The surface of the filament will, of course, greatly affect the amount of current required. A thin filament having smaller surface, and therefore radiating less heat per unit of length, will require proportionately less current than even its resistance would give it to produce a certain amount of light. The mechanical strength of the filament itself, and its connection with the platinum wire that brings the current to it, also form important points in the construction of the lamp.

The other incandescent lamps, although their owners usually adopted some form of globe and connection differing slightly from the arrangement of the Swan lamp, really only differed in the substance and form of the filament. Edison used carbonised bamboo; Maxim, bristol board; Lane-Fox, bass broom; Crookes, carbonised cotton.

The owners of the MAXIM lamp claimed that theirs was far superior to any other, both in the amount of light given out and in the duration. The writer tried on several occasions samples sent to him especially for trial, but could never get anything like the same light for the same current as with Swan's.* It is stated that the lamp lasts a long time,

* Since the above was written the writer has had occasion to compare Maxim, so-called 50 candle-power lamps, old pattern, with Woodhouse-Rawson 20 candle-power. A few lamps were required on a circuit where the former were in use, and the writer having reason to believe, from some measurements he had made at Risca Colliery, that the Maxim 50 candle-power was not an economical lamp, advised a trial of some 20 candle-power on the same circuit. The 20 candle-power lamps were made specially to the same electro-motive force that the Maxim 50 candle-power were taking; when connected to the same wires they gave a far superior light to the so-called 50 candle-power, and with about 50 per cent less current.

nevertheless the owners of the patent appear to have abandoned it now in favour of another taking less current, which they now claim as superior to anything in the market.

The LANE-FOX lamp apparently succumbed to some difficulties in manufacture.*

The CROOKES lamp, owned by the Gülcher Company, presented many good features, particularly in the strength of the glass, but it seems not to have made much way.†

A new lamp, on the same lines as the Swan, called the WOODHOUSE and RAWSON lamp, is the only one that promises, so far as the writer's experience goes at present, to rival the Swan. Its owners claim that it requires less energy per candle to produce the light, and that it lasts longer. So far as the writer's trial has gone at present it certainly bears out these claims. Really, however, in the matter of lamps as in dynamos, it is careful work that is most to be sought for.

CONNECTIONS.

Having a generator producing a current and lamps consuming it, how are the two to be connected? This is done by means of copper wires. There are two or three important points to be remembered here. Conductive resistance must be as low as it can possibly be made, for the double reason, that if the resistance is high the wires may heat, extra work is done and a certain amount of the available electro-motive force at disposal is wasted in overcoming the resistance of the wires, etc. leading to the lamps, and as much of it may be expended before coming to the lamp, there will not be sufficient to drive the requisite current through it. The insulation of the wires must be sufficiently high to prevent waste of any magnitude taking place.

In practice, either stout single copper wires, or a number of thinner ones stranded together, are used for carrying large currents, such as those used for arc lights, or for a number of incandescent lights. These will, however, if economy is to be practised, be proportional to the currents they have to carry.

The writer has named arc lights as follows: No. 1, that which takes 20 ampères and upwards, and is known variously as from 5,000 to 6,000 candle-power. It is a light that when placed 20 feet high enables a person 100 yards from the light to read a newspaper. No. 2 is an arc taking

* The writer understands that this lamp has been revivified under the name of the Victoria.

† The writer learns that the directors of the Gülcher Company have definitely abandoned the manufacture of the Crookes lamp.

from 10 to 12 ampères and usually known as 2,000 candle-power. A person can read at a distance of 30 yards from this. No. 3 takes 5 to 6 ampères and is known as a 500 candle-power; and to read a news paper a person would have to be at from 15 to 20 yards from it. A wire equal to No. 7 old Birmingham wire-gauge will easily carry the current for No. 1 arc without the slightest heating. No. 11 will carry the current for No. 2 arcs; No. 14 for No. 3 arcs.

In these gauges very liberal allowance is made for the heating effect; but every case really has to be determined by itself, so much depends on the machine that is being used and the electro-motive force that is available. Suppose, for instance, that in a circuit of No. 1 lamps there is a mile of leads. No. 7 copper wire has a resistance of 1·7 ohms per mile. To deliver 20 ampères through this an electro-motive force is required by Ohm's law of 34 volts. $E = C\,R = 20 \times 1{\cdot}7 = 34$ volts, which is sufficient for an arc light. It has then to be considered whether an additional arc shall be sacrificed to obtain economy in the leads, or whether another arc shall be used and have larger leads.

Supposing a wire whose resistance was only ·5 ohms for the mile. This would give $E = C\,R = {\cdot}5 \times 20 = 10$ volts, an electro-motive force that can be obtained if necessary, in most cases of arc lighting in series, by driving the dynamo a trifle faster. It is possible, in fact, to work to any conditions. Knowing the current required and the electro-motive force that can be safely spared the resistance of the wires required can readily be found. To take a case: Suppose a Gramme machine delivering 40 ampères at 50 volts, and it is required to deliver the current for 30 incandescent lamps at the bottom of a pit, say 300 yards deep, 5 volts for the leads can safely be allowed—

$$C = \frac{E}{R} \therefore R = \frac{E}{C} = \tfrac{5}{40}$$

$$R = \tfrac{1}{8} \text{ ohm.}$$

From this it will be found that the 600 yards of wire to deliver the current for the 30 lamps, with an available electro-motive force of 45 volts at the pit bottom, must only have a resistance of $\frac{1}{8}$ ohm.

If it were certain, as in most cases it is, that sufficient light would be obtained with 40 volts, the wires in the shaft might be half the size, provided they were still sufficiently large to avoid heating. The reason will now probably be seen why such a liberal allowance is made in the size of the wires for arc lights. Half a mile of wire is soon expended about a colliery of any size when it is remembered that, with the series arrangement, the wire has to go from the machine to each lamp in succession

and then back to the machine. This, with the resistance of connections, etc., would give very nearly one ohm, with No. 7 wire for the leads, and an electro-motive force absorbed in the leads with No. 1 arcs of 20 volts, which is about as much as any series dynamo can spare unless it is underworked. Of course, it will always be possible, by having surplus electro-motive force in the machine, to use smaller wires within the safe heating limit, but even here, with machines for incandescent lighting, there will very rarely be more than 5 or 10 volts available. The question of the heating of the wires, which is a very important one, depends on several variable conditions. A copper wire stretched naked in air will safely carry a larger current than a covered wire, since more heat will be radiated from its surface. A wire covered with a substance, that, while insulating for electrical purposes, allows the passage of heat rays more or less freely (such as India-rubber), and will not readily melt or burn, can also carry larger currents than wires covered with substances such as gutta-percha that soften in the presence of heat, and that do not so readily allow of the passage of the heat rays. Again, time has a very important bearing on the question of heating. If the heat is not radiated or conducted away from the surface of a conductor as fast as it is generated the temperature of the wire must rise, and however small the increment of rise may be, if time be allowed, it must reach a dangerous degree, so that, other things being the same, the wire that has to convey currents for long periods should either have less heat generated in it than those which convey the currents for shorter periods, or have greater facilities for dispersing it. This applies very particularly to underground lighting, where the lights will be run almost continuously for six days every week. Further, where a wire is coiled on itself, as in the coils of a dynamo or electro-magnet of a lamp, the current that can pass with safety will be less, owing to the less favourable opportunities for the heat to escape.

The next important point in connection with wires is the insulation. The importance of this rises, as will easily be seen, with the electro-motive force in use. Defective insulation that would be of no consequence with an electro-motive force of 50 volts may become a serious matter with 2,000 volts. The minimum insulation resistance allowed on ordinary telegraph wires, consisting of naked iron wire secured to insulators, carried on poles, is 100,000 ohms per mile, that is to say, the resistance of the 20 to 25 branch circuits to earth formed by the insulators, brackets, and poles combined must not be less than 100,000 ohms in a mile; in half a mile it would be 200,000 ohms; in 5 miles, 20,000; and in 10 miles, 10,000. Now, with an electro-motive force of 50 volts,

with lamps run in series, the lowest of these figures means a loss of only $\frac{1}{200}$ ampère on the way, which would be inappreciable; that is to say, the current arriving at the farthest lamp would be weaker than that setting out from the generator by $\frac{1}{200}$ ampère, and the work done by this current would be represented by—

$$W = E\,C = 50 \times \tfrac{1}{200} = \tfrac{1}{4} \text{ watt.}$$

With 2,000 volts the case is a little more serious. $\frac{2,000}{10,000} = \frac{1}{5}$ A.

$$\tfrac{1}{3} \text{ A} \times 2{,}000 \text{ v.} = 400 \text{ watts} = \tfrac{1}{2} \text{ h. p. about.}$$

But suppose the wires have been badly put up, or allowed by neglect to lose their proper insulation, either by having the insulators broken by stone-throwing or the wires improperly fixed to the poles by staples; or led over iron roofs, girders, or otherwise badly laid in any of the numerous ways ignorance can suggest so easily, the resistance might even in a comparatively short time fall to 1,000 ohms.

$$C = \frac{E}{R} = \frac{2{,}000}{1{,}000} = 2 \text{ ampères.}$$

$W = E \times C = 2 \times 2{,}000 = 4{,}000$ watts, representing about $5\frac{1}{2}$ h.p. absolutely wasted, and forming a source of danger. The fires that occurred in the early days of practical electric lighting, which the writer believes were principally, if not entirely, in America, were due to two causes—the use of high tension currents, and neglect of insulation. Wires, between which very great difference of tension existed, were stapled side by side on the same board; sometimes the board got saturated with water or oil, and gradually became a sufficiently good conductor to admit the passage of a small current between the two wires. Carbon was immediately deposited, increasing the conductivity, and at last so much current passed, at some particular spot, that great heat was generated and the wood was ignited.

In other cases naked wires with high tension currents in them, were left near together with inflammable substances between, a sudden change in the electrical condition of the circuit gave rise to an *extra* current, which, taking the form of a spark, ignited the inflammable substance between the wires.

These are, of course, extreme cases, but they will serve to illustrate both the dangers of electric lighting and the perfect safety of electric lighting currents when proper arrangements are made.

The wires on dynamos and the electro-magnets of lamps are simply covered with two coatings of cotton, the great object being to get as much wire as possible into the available space, and each layer close together.

It follows, of course, that currents of greater strength than the wires are calculated to carry, char and burn up the cotton covering, rendering the machine or lamp for the time being useless. It will be explained later how this may occur, and how it may be avoided.

For leads from dynamos to lamps and back again, naked wires may be used quite safely, supported on ordinary telegraph insulators fixed in the usual way, provided it can be ensured that there shall be no danger of two wires, or two portions of the same wire, coming into contact with each other. Should such an accident occur during the time currents were passing through either of the wires, it would probably result in serious damage to them, and possibly to the machine, if the contact removed much resistance from the circuit. Sparks would pass, burning the wires, and if the electrical conditions of the circuit were sufficiently altered they might be completely fused, unless the engine was stopped in time. It comes, of course, to the same thing, if another conductor, such as a piece of copper wire, be thrown across the two wires.

In towns, the writer is very strongly of opinion that no naked wires for electric lighting should be allowed, except in very exceptional cases. Should an electric light wire, in which a current was passing, get into contact with a telephone wire, it might cause a fire in the building where the telephone apparatus was fixed, should some sudden change, as a break in the electric light circuit, take place. Wires covered simply with a plait of cotton or jute have been used, but these are not safe for street work. With low tension currents all would be well, so long as the cotton was in the same perfect state as when delivered by the manufacturer; but the cases in which this could be depended on would be rather the exception than the rule. Wet, oil, even a change of temperature might create a condition of things favourable to the passage of a spark between wires lying together, which risk would be, when the tension is high, intensified very much.

The substances to be relied upon are then :—

Asbestos, some forms of which for wire covering are now coming into use. The writer has had no experience with this, and is doubtful of its efficacy by itself.

India-rubber, now almost universally adopted. This substance gives a very high insulation resistance, several millions of Ohms per 1,000 yards. It permits the passage of the heat rays through it, and it lends itself very readily to form with a strand of wires, a flexible insulated conductor easily fixed. It has one great drawback in the case of mines; it will not withstand wet, and particularly the water that is to be

found in colliery shafts; it softens it and makes it an imperfect conductor. Covered with a thick, complete, and impervious envelope of jute, it answers well, so long as the jute lasts entire. It is also made and drawn into lead pipe, which is very suitable for shafts, always provided that the leaden envelope remains perfectly intact.

Gutta-percha is adopted in many cases, especially where from wet or other causes India-rubber cannot be used without large additional expense. Care must be taken in using gutta-percha that the working current is so proportionate to the wire as to generate very little appreciable heat, otherwise the gutta-percha will soften, and the wire may then, in certain places, fall through and destroy the insulation entirely. Gutta-percha covered wire is especially suitable for connecting wires in mine shafts, where there is always more or less moisture.

For connecting the main wires to single incandescent lamps, small wires, No. 20 to 22 B.G., covered with india-rubber or gutta-percha, and then with cotton, are very suitable. A very substantial form that the writer has used consists of a cable in which are enclosed two No. 21 B.G., wires, each covered with a complete envelope of vulcanized India-rubber, the two being laid over with jute, and then with two coatings of tape saturated with some waterproof substance.

It now only remains to describe the manner in which the connections are made between dynamo lamps and wires, and also the arrangements for extinguishing or lighting any particular lamp, for protecting lamps and machines in case of the accidental passage of an excess of current, the instruments used for measuring, &c.

Arc lights may receive their current from the dynamo in four different ways:—First, in series where the wire on the electro-magnets, the wires leading to the lamps and the lamps themselves, form one continuous circuit with the two halves of the armature of the dynamo. Fig. 6, Plate I., shows this arrangement, in which the strength of the current is always the same, whether one light is being furnished or the full number that the machine is capable of. It will be remembered that the electro-motive force developed in any dynamo-electric machine depends on—

1. The strength of the magnetic field.
2. The number of turns of wire on the armature.
3. The speed of rotation.

With the series machine, then, provided the strength of the current is maintained constant, the electro-motive force will depend simply on the speed.

Suppose the terminals of the machine to be connected together in what is technically known as short circuit, that is, by a conductor whose resistance is practically inappreciable, the armature will require to be driven at a certain limited speed to charge the electro-magnets. If the short circuit be taken off and the leads only connected with the machine, the circuit being closed through them, the extra resistance offered by the leads will reduce the strength of the magnetizing current below the proper working limit, unless the speed of rotation of the machine be increased, thereby reducing the magnetism of the electro-magnets, and again reducing the electro-motive force developed, so that the current would be actually less than it should have been, simply from the addition of the resistance of the leads to the other previous conditions. By slightly raising the speed, the current is restored to its proper strength. Now if one arc light is switched in, its electro-magnet strikes the arc and introduces a large increase of resistance, and the same thing takes place as when the leads were connected, except that the light will probably refuse to burn until the proper speed is reached. When a second arc is switched in, the speed is again increased, and so on. In practice, the proper speed for any number of lights is known; and on starting, the number required is switched on, and the engine set to that speed. If with any given number of arcs in circuit, the dynamo should not be running at its proper speed, the lights will feel it. If below speed, one or other will constantly be bobbing out; if above speed, one or other constantly flaming and burning blue. Each time a light goes out, owing to the carbons coming together, there is an increased throw of current through the circuit, causing extra heat everywhere, especially in the machine, and an extra pull on the engine, which usually responds to the pull by slacking speed, adding to the mischief. There is, however, not the slightest difficulty in arranging the speed with proper appliances. The size of the arcs, of course, affects the speed of the dynamo, as does also the current used.

Supposing a machine to be furnishing, say, six arc lights. If these are very small, and are kept so, their resistance will be very much less than if they are large, consequently the machine would have to run at a much lower speed with a given number of small arcs than with the same number of large ones.

With very many lamps, however, notably the Brush and Weston, the length of the arc is almost entirely beyond the control of the engineer, except in so far as he can keep his engine at one uniform speed and all his apparatus in first-class order; and as the circuit and the engine almost

invariably re-act on one another, the effect following *after* the cause, this is a most difficult thing to do. With the Brockie it is not so. So long as all is working properly, the length of the arc remains absolutely constant; and further, if more light is required in one place and less in another, one arc can be made long and another short without interfering with the others, provided the limits of the machine be not exceeded.

It may be well to point out here that, leaving reflectors and other aids out of consideration, the light given out by an arc lamp depends upon the current passing and the length of the arc. A small current may give as much light as a large one within certain limits, if the arc is longer in the former case. There is, however, a working limit beyond which increased length of arc cannot go, and a useful limit beyond which the light becomes blue and ghastly.

The speed of any given dynamo, furnishing a given number of arcs of a given total resistance, is also largely affected by the strength of the current that is required to be driven through them.

Suppose a circuit of six arcs requiring a current of twenty-four ampères. If the conditions are such that sufficient light can be obtained with, say, from 18 to 20 ampères, though the magnetic field will be weaker, owing to the reduced strength of the current, yet it will be found that the speed will also be considerably less. It will take a higher relative speed than if the machine had been constructed to work with the smaller current, but not so high as would be required to furnish the full current. It is possible even to work an increased number of lamps by using a smaller current, provided the lamps are, or can be, arranged for it. This can always be accomplished with the Brockie commutating lamp.

The connections of the feed or branch wires, the wires that carry the currents to the electro-magnets of the lamps, with Brockie commutating circuits, require special notice. They form a loop or shunt of the main circuit from the positive terminal of the machine to the positive side of the positive lamp.

The resistance of the wire leading from the machine to the positive lamp necessitates a certain electro-motive force to overcome it, and that electro-motive force is made use of to drive the necessary current through the feed wires. The current divides at the positive terminal of the machine, between the main wire leading to the first lamp, which may conveniently be made the farthest from the machine, and the feed wires leading to the electro-magnets of the lamps. After passing through the latter, the feed wires all connect to the positive wire, and their currents join with the currents passing in that, and flow through the rest of the

circuit. Fig. 8, Plate VIII., shows the arrangement. The condition of the feed wires joining the positive wire *before* it enters the lamp is necessary, otherwise should they join at any point on the negative side of that, they, forming then the path of the least resistance from the machine, would convey the current direct to that point, leaving out any arcs that might be on the positive side of them.

This arrangement ensures that there shall be no waste, and that the whole current furnishes light. Where the resistance of the main wire connecting the positive lamp with the dynamo is not sufficiently large to give the requisite electro-motive force for the feed wires, it may be increased by the introduction of an artificial resistance into the main wire, as shown. This may be accomplished by making the main wire smaller or by inserting a short piece of iron or German silver wire in the main circuit. It can, of course, be done by increasing the relative size of the feeds to the main. The latter plan wastes the least electro-motive force, the former is most economical in the cost of wire.

The next arrangement of arc lamps is to run them in derived circuit from a low resistance machine, which in this case would be either shunt or compound wound; each lamp receiving its current direct from the machine, either by separate wire or by a large cable representing the whole number. Fig. 3, Plate IX., shows a set of Brockie lamps in derivation. This plan presents two difficulties. It increases the cost of the wire very much, almost as many times as there are lamps, and in addition the circuits have to be carefully balanced to take no more and no less than their own proportion of current. If they take more they deprive the other lamps, and if they take less they throw a surplus on the other lamps. In other words, if their arcs burn longer than they are set for, the other lamps get more current than they should; and if a lamp goes out, through its carbons coming together, there is a strong probability that by depriving the electro-magnets of the other lamps of their proper current, some of them may be put out also.

So far as the writer is aware, only a few lamps have yet been tried in this way. The Brockie, as usual, lends itself to it very readily; and the Gülcher, the original lamp, appears to have been specially designed for it.

The arrangement possesses one or two great advantages. Provided the lamps work well, they are quite independent of each other, the entire removal of one does not affect the others. Different sized lamps may be run together from the same machine. Arc and incandescent lamps may be run together from one machine, without the special precautions necessary in running with series machines, but the respective circuits

must be properly balanced. As arc lamps usually require a lower electro-motive force than incandescent, an artificial resistance would generally be required in those circuits working the former. Electro-motors may also be worked in this arrangement, more readily than in series; that is, in connection with, or alternatively to, arc lamps. With a dynamo of very low resistance in proportion to the resistance of the branch circuits, it may be arranged that lamps may go in or out without affecting the others. The dynamo also always runs at one speed, no matter what work is on, instead of increasing or decreasing with the number of lights as with the series.

The next plan, running the arcs in series from a shunt-wound dynamo, presents no important differences from the series arrangement, except such as arise from the difference in the winding. The working is steadier, since variations in the resistance of the external circuit are compensated, within certain limits, by the necessary variations in the electro-motive force delivered by the machine, without altering the speed.

Thus, should the arcs increase and cause an increased resistance in the main circuit, a larger current will flow into the shunt exciting circuit, producing, if properly balanced, the necessary increased electro-motive force requisite to maintain the current constant, and *vice versâ*. With the series machine the reverse is the case.

Very little has been done yet with arc lamps in series worked from a shunt wound dynamo, owing probably to the greater simplicity of the series method.

The only other method is the same as the last, except that the dynamo is constructed on Mr. Charles' beautiful modification of the compound winding, where the speed is maintained constant, no matter how many lights are turned in or out.

It may be remarked that, with proper lamps, far larger variations in the currents furnishing arc lights are permissible than could possibly be allowed with incandescent lamps, where every variation, even the passage of a badly made joint in a driving belt over the pulley, is distinctly and painfully shown.

The current may be led to incandescent lamps on any of the arrangements described for arc lighting. With a series dynamo, a series of parallels of incandescent lamps are formed as shown in Fig. 4, Plate IX. Each parallel consists of a certain number of lamps, depending on the current that the machine will furnish. The number of parallels depends on the electro-motive force developed by the machine at its highest safe speed.

Thus, with a machine giving, say, 20 ampères and 200 volts, if each incandescent lamp requires a current of 1·34 ampères and 48 volts, there will be:—

$$\frac{20}{1{\cdot}34} = 15 \text{ roughly; and } \frac{200}{48} = 4 \text{ nearly.}$$

Therefore four parallels of 15 lamps each or 60 in all, can be worked with a margin of 8 volts for leads, supposing that the lamps are worked up to their full 20 candle-power. By sacrificing some of the light given by each lamp more lamps can be used. The great drawback to this arrangement for incandescent lamps is that it renders great care necessary that the parallels are all equal. Should there from any cause be one lamp less in one parallel than in the others, the others in that parallel have each $\frac{1}{14}$ more current to carry, and if another goes out, the remainder are still more over-worked; perhaps then another lamp or two, that would have lasted some time if it had been only required to stand its proper current, gives way under the extra strain and so on. This is further intensified where arc lights are worked in the same circuit with incandescent. Every change in the arcs is reflected inversely in the incandescents, since the whole current that the arcs will allow passes through the incandescents. Should an arc burn long, unless the engine increases its speed, the resistance of the circuit being increased, the current strength falls, and with it the light given by the incandescent lamps. Conversely, if the carbons of an arc lamp come together or the arc decrease, there is a sudden throw of current through the circuit, owing to the decreased resistance, that causes the incandescents to brighten up. An apparatus called a fusible cut-out, that will be explained later, has been sometimes inserted to save individual lamps or groups of them.

The writer established an installation of four arc and forty incandescent lamps at Cymmer Colliery in South Wales, worked by an E Gramme machine, the incandescents being worked well under power. Each arc was fed by a separate wire, and great care was taken that the break in the feed current of each was of very short duration. Each arc lamp was guarded by an automatic cut-out, which, when an arc from any accident increased beyond a certain size, cut it out of the circuit, allowing the current to go by another path. Each parallel was protected by another automatic device, which instead of putting the lamps out, simply carried off the surplus current by opening to it a new path whose resistance decreased as the requirements of the circuit increased. The installation was, however, only successful so long as the men who fixed

the work remained; the attention required was more than the lad, who was put in charge, was equal to; the writer is now engaged converting the machine to the low tension method.

Walker and Olliver's Automatic Regulator for incandescent lamps, as arranged to carry off the surplus current that may pass through the circuit from increased speed of the engine and other causes, thereby avoiding the entire strain brought on the lamps and yet not putting them out as with a fusible cut-out, may be thus described.

An electro-magnet wound with fine wire, proportioned to the electro-motive force of the circuit, is bridged across the mains, its wire forming a branch with that of the incandescent lamps and taking a certain small portion of the current, in accordance with Ohm's law. Facing the pole of the electro-magnet is the usual iron armature, pivoted near its centre, and carrying at one end a short carbon pencil. At the other end of the armature is a spring, whose tension can be adjusted, and which opposes the pull of the magnet. Facing the carbon pencil is another, and between this second carbon point and one chain, a variable resistance, usually a 50 or 100 candle-power lamp, is inserted.

The armature is connected to the other main, so that when the electro-magnet has acquired sufficient strength to overcome the pull of the spring, the two carbon points come together and open an additional path for the current by way of the armature, carbon points, and 50 or 100 candle-power lamp. The additional current that would otherwise be divided between the incandescent lamps the apparatus is placed to protect, now passes by way of this extra path, and as it is evident that the resistance of this path, or in other words, its capacity for carrying off current, can be made as large or small as required, the protection is very perfect. Immediately that the cause, temporary or otherwise, of the additional current is removed, the tension of the spring overcomes the pull of the magnets, the contact between the carbon points is broken, and the circuit is restored to its original state.

The apparatus works very beautifully, and exactly in accordance with the requirements of the circuit. There are two variable resistances: the resistance offered by the carbon contacts, according to the now well-known principle of the microphone, and the resistance of the incandescent lamp that is thrown into circuit. For instance, with a small increase of current, the carbon points are thrown into light contact, the resistance of which may be very considerable, while only a small current passing through the 50 or 100 candle-power lamp, its resistance remains nearly what it is when cold, nearly double of what

it is when hot. A larger increase makes firmer contact between the carbon points, lowering their resistance, and as more current now passes through the lamp, its resistance is also lowered.

The by-path may not necessarily consist of only one lamp. Two or more could be used where greater capacity is required; or, where a large number of lamps are in use, and subject to large fluctuations, two or more regulators may be attached, each one requiring a little more current than its neighbour, before coming into action.

There is another point to remember in running incandescent lamps from a series dynamo with several parallels. The same rule applies as to speed and current through a given resistance, as in arc lighting; With a given number of lamps in each parallel, and a given number of parallels, the greater the strength of current required the greater must the speed be. Further than this, however, with a given number of parallels, the *smaller* the number of lamps in each parallel, the higher will the resistance of each parallel be, and, therefore, the greater speed. It is like increasing the size of the arcs.

The next plan, and the one now almost universally adopted for incandescent lighting, is to use a low resistance dynamo, excited by a shunt or compound series and shunt. A few low resistance dynamos on the series principle, where the electro-magnets are excited by the branches of the main circuit, are still in use, such as the B Gramme and the original Gülcher, but they are fast becoming obsolete. The compound wound machine, which allows lights to be turned out or in at will, without altering the speed of the machine and without affecting the other lights, is fast superseding all others for incandescent lighting. With this arrangement all the lamps are arranged in one parallel; mains of varying sizes are led out to where the lamps are required. Plate XI. shows the arrangement of fifty lights fixed by the writer's firm at Eppleton Colliery belonging to the Hetton Coal Company.

With all incandescent lighting, two main wires between which the necessary electro-motive force exists, whether derived from a series, shunt, or compound wound machine, are led into the neighbourhood of the position that the lamps are required in, and the small branch wires are then connected one to each main wire, the other ends of the branches being connected to the terminals of the lamp.

The description of a few necessary accessories and faults that occur will complete the information at the writer's disposal.

SWITCHES.—These are apparatus designed to cut off the current from

one particular path, and either to break it altogether or to turn it into another path. Each arc lamp is usually provided with a switch to turn it out when not required. When the arcs are run in series, the switch turns the current into a by-path, which avoids its own lamp and passes on to the next.* In derived circuit, the circuit is simply broken. With the Brockie commutating lamp it is best to break both main and feed wires. Figs. 5 and 6, Plate IX.; and 2 and 3, Plate X., show switches designed for arc lamps or for batches of incandescent lamps. Incandescent lamps may be turned out in batches. If run from a series machine, a whole parallel is turned out by bridging it across. When run from a shunt machine, the switch merely breaks the connection of one wire before it reaches the lamps that have to be cut out. Individual lamps can be switched out separately by smaller switches. Figs. 4 and 5, Plate X., show switches for single lamps.

HOLDERS.—These are to bring the filament connections to terminals, and at the same time form a handle for the lamp. They can usually be screwed into gas-brackets, taking the place of the gas-burner. Fig. 6, Plate X., shows a holder and switch combined. Figs. 7 and 8, plain holders. Fig. 10, a plain iron bracket designed by the writer for colliery work: it has a point at one end to drive into wood, &c., and carries a gas-nipple at the other, into which the holder screws.

AUTOMATIC CUT-OUTS FOR ARC LAMPS.—These may be worked in two different ways.

1. An electro-magnet fed by a wire forming a shunt to the arc, the pull of which is opposed by a spring, makes contact, and thereby opens a path for the current avoiding the lamp, when the arc having attained a certain size, the shunt wire receives sufficient current to enable the magnet to overcome the tension of the spring.

2. The electro-magnet may be fed by a wire forming part of the main circuit, in which case contact is broken as soon as the current has strength enough to pull the armature down in opposition to the tension of the spring. Should the arc attain such a size that the current passing round the magnet is not strong enough to overcome the tension of the spring, the force of the latter makes contact as before, opening a pass-by circuit.

These can be attached to any arc lamp. They consist simply of an electro-magnet fed by a shunt across the arc, or a wire in the main circuit; the armature carries a contact piece, which, when the arc reaches a certain size, regulated by the tension of a spring attached to the

* In Fig. 5, Plate IX., terminal a would be connected to the main wire from the dynamo, a^1, the wire leading to the lamp, and a^2, the wire leading to the next lamp.

armature opposing the pull of the electro-magnet, makes contact with another contact piece, and the current then passes by another path leaving the arc. As soon as the carbons come together again the electro-magnet loses its pull, the automatic pass-by contact is broken, and the arc is re-formed.

In the installation at Cymmer, the automatic cut-out throws in a roup of incandescent lamps inside the lantern containing the arc lamp.

Fusible Cut-Outs.—These are constructed to break the circuit entering a group of lamps or a single lamp, should a dangerous current pass into them. They consist simply of two pieces of brass, supporting between them a strip of alloy that is arranged to fuse and break the connection to one of the wires should a current of a certain predetermined strength arrive. The apparatus is a very useful, but a very barbarous one, and will, in the writer's opinion, be superseded before very long, by some such arrangement as that designed for Cymmer.

When electricity becomes general, as gas is now, the idea of all the lights in a house being cut off, because of some trifling fault in the wires, or at the generating station, will hardly be tolerated.

Measuring Instruments.—The only two that need be described here are the ampère meter and the volt meter. These are of various forms according to their different designers or makers; but they all depend on the action of the current upon a magnet, through the medium of coils of insulated wire surrounding it, in opposition either to the pull of a powerful permanent or electro-magnet, a spring, or, in the simplest form, of gravity itself, in which latter case a weighted needle is used. The two sets of instruments are usually made exactly alike in every particular, except that for the ampère meter, a short length of thick wire or strand of wires is used, giving merely a nominal resistance, and in the volt meter, a very long length of thin wire is used, giving a very high resistance. There is in each case a light pointer which traverses the dial under the action of the current.

The ampère meter is inserted in the circuit, or branch, the whole current going through its coils, and the deflection of the needle forms some known ratio to the strength of the current.

The volt meter is bridged across as a shunt to the portion of the circuit, between the extremities of which it is required to know the electro-motive force, the current that any given electro-motive force is able to force through the high resistance shown by the readings of the pointer being a correct measure of that electro-motive force.

The use of the ampère meter is to show the current passing in the

circuit at any moment. By having one of these near the engine and dynamo, the engineman can tell at a glance if all is right so far as he is concerned. With arc lights in series his pointer should always be at the same figure and he works to that no matter how many lights are in circuit. With a lot of work, whether arc or incandescent, or motors, fed by a low resistance dynamo, he knows what deflection corresponds to a certain number of lamps and he works to that.

The principal use of the volt meter is to test for faults with incandescent lamps, and to test the loss of electro-motive force in passing through any set of wires. Noting the deflection on one side and then on the other, should there be an unusual fall, further intermediate tests will show the cause.

THE ENGINE OR MECHANICAL MOTOR.—Any kind of well-made steam, air, gas, or water motor that can be made to run at a constant speed, will answer for electric lighting. Any large engine about the works, such as the fan or workshop engine, that runs, or can be made to run always at one uniform speed, will also serve the purpose, but no irregular running engines such as air-compressing engines, blast engines, &c., will do. So far as the writer's experience goes, any well-made engine, provided it has a plentiful supply of steam and a good high speed governor, will give very good results. The governor balls require to be regulated to cut off promptly at the slightest increase of speed. For arc lighting very much more latitude can be given than lighting with incandescent lamps. With good arc lamps, particularly the Brockie, a difference of 10 per cent. is hardly felt, but with incandescent lamps everything must be perfect. The smallest alteration in the speed, even the passage of the splice over the pulley unless very carefully made, is painfully visible. It is the practice of the writer's firm always to have either a sewn joint, or one of those special forms such as Angus's chain belting where the thickness of the belt is the same all through. The writer has used chain belting with success, and as it is the same size all over it possesses the great advantage of being easily and quickly taken up as it stretches.

To find the horse-power required for any installation of incandescent lamps. Determine first all the resistances of the circuit including that of the generator, or the total electro-motive force of the circuit and the currents delivered. Then by means of the formula—W. in h.p. $= \frac{C^2 \times R}{746}$ or $= \frac{E \times C}{746}$ find the horse-power actually used in the circuit. Should there be any leakage current, this must also

be taken into consideration, but the cases in which it would be required are rare. To this add 10 per cent. for the loss by friction, heating of iron, &c., this will give the total horse-power that must be *delivered to the pulley of the dynamo.* By adding to this the loss in the belt and the engine the indicated horse-power can be readily found. This, however, is the minimum power that can do the work under the best conditions and with everything in first-rate order. It allows nothing for increased friction, dirty joints, &c., so that it is wise to allow a good working margin over and above whatever this shows. To take an illustration: say there are five arc lights run from an A2 machine. The current is 12 ampères, the resistance of leads 1 ohm, of lights 3 ohms each, of machine 3 ohms; total resistance equals $1 + 15 + 3 = 19$ ohms. W in horse-power expended in electrical energy $= C_2 = 12^2 \times 19 = 144 \times 19 = 2736$ watts. To this add 10 per cent. for conversion = 274 watts. Power to be delivered to pulley of dynamo then equals 3,000 Watts = roughly 4 horse-power. By adding to this the power consumed in engine and belting which the writer thinks may fairly be left to mechanical engineers, the power required in indicated horse-power in the cylinder is arrived at.

FAULTS.—The only points remaining to be touched upon are the faults that occur in working and the parts that wear. With well-made apparatus properly fixed the faults should be few and far between: wear and tear is very trifling, and is, or should be, confined to the bearings, the brushes, and the collectors of the machines. Care must of course be taken to keep the bearings well oiled and to replace them when worn to a certain amount, otherwise, as the distance between the outer wires of the armature and the pole pieces of the electro-magnets is always made very small, the former will fall down and cut themselves on the latter, rendering the armature useless. The brushes require to be carefully trimmed periodically, the time depending on the amount of work done by the machine, and to be set on the commutator so as to give the minimum amount of sparking. The greater the sparking the quicker do both commutator and brushes wear. A badly trimmed brush will wear both itself and the commutator in a few hours very considerably, as much, or more, than in many weeks of ordinary work if properly adjusted. As the commutator wears down, if it be of the Gramme form, it usually wears in a more or less irregular groove. The practice has been to put the bobbin in the lathe and turn it down level. It is better, if possible, to avoid doing this. If it cannot be avoided, great care must be taken that two of the segments on the commutator

are not connected by the tool in turning, carrying a small piece of one segment over to the next. Should such an accident happen it will probably lead to the destruction of the insulation of that coil. It is quite easy to avoid this, however, by carefully cleaning out each division after turning it up. Care must also be taken that wires of neighbouring coils other than those connected together do not come into contact, nor the radial pieces to which they are attached, and that pieces of metal are not left in contact with the radials. None of these should happen, except through the great carelessness of the man in charge.

Another fault that sometimes, though rarely, happens, is, if in any form of armature the wires be not securely bound in with a substance that will withstand both the heat of the wires and the centrifugal force of the bobbin, the latter will expand, and the outer wires will cut themselves on the poles of the electro-magnets. This is easily guarded against by having a binder of thin wire soldered together all round outside the tape that is generally used.

A fault that occasionally occurs, more particularly with incandescent lighting, is, the two main wires may come into contact, either by being stapled together, or from some accidental cause, such as in making a joint. The result is that without any apparent cause the lights refuse to burn, and even the closest scrutiny fails to detect the cause, owing, possibly, to its being covered up. In such a case the cause may readily be found by turning on a sufficient current for testing, cutting one of the main wires in two or three places in succession, and joining them up again after each cut until the fault is passed. At each cut, those lamps on the dynamo side of the cut will go in if the fault is beyond it, and so on; the cause of the lights refusing to burn being that the current all passes by the shorter path across the contact and refuses to go by the lamps. When the contact is cut off from some of the lamps by cutting the wire they immediately light up. A fault of this kind may, by allowing a too powerful current to pass round it, cause the burning of the coils of the bobbin in a fine wire machine.

Perhaps a few words on the matter of the carbons used with arc lights may serve to bring the paper to a close. It is a mistake in this, as in everything else, to buy these too cheap. If they contain impurities, such as silicon, magnesium, etc., which the earlier English-made carbons did, and those cut from gas carbon invariably do, the result will be, even under the very best conditions, imperfect working of the lamps. As the carbon burns down, suddenly a piece containing one of these substances comes into the heated part and causes the light to fizz, splutter, and go

out. This is caused by the material fusing at a lower temperature than the carbon, and perhaps breaking an inch or so of it. Carbons, too, should always be dry. By the seaside it frequently happens that the carbons, which are more or less porous even at their hardest, become impregnated with the volatilized salts that rise from the sea, the result being more or less flickering in the arc until the heat has driven them out again. This can easily be avoided by keeping them in a warm place, and, where this cannot be done, by using them covered with a coating of electrotype copper. Carbons are also now made with a core of thin wire or some soft substance conducting slightly better than carbon, the object being to keep the light to the centre and avoid its burning on one side, as it sometimes does. They are, however, more expensive and tend to colour the light.

The writer believes that he has now communicated all the information on the subject of electric lighting that is available up to the present, and, though the paper has grown, in spite of his endeavours, to a great length, he hopes it may be of service to the members of the Institute, and of some slight help in the advancement of electric lighting for mines and works.

Anything that may have been inadvertently omitted, or not rendered sufficiently clear, he will be most happy to explain, so far as his experience goes.

APPENDIX.

Secondary Batteries, or Electrical Accumulators.—In writing his paper some months back, the writer did not think it necessary to refer to accumulators as they had then hardly acquired a practical form. Since then, however, they have made great strides, and he hopes that the following may be of service.

Secondary batteries, or electrical accumulators, are simply galvanic batteries, in which, when perfect, no consumption of materials takes place. In principle they are closely analogous to the hydraulic accumu-

To illustrate Mr Sydney F. Walker's paper "On the Principles of Electric Lighting."

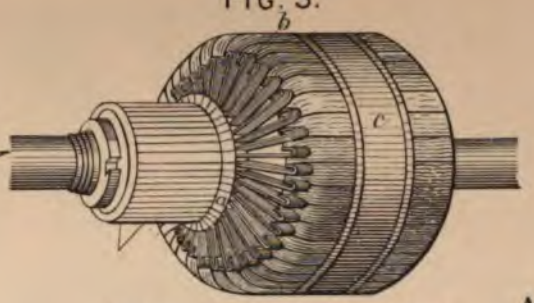
FIG. 1.

IRON WIRE CORE ON GRAMME RING.

FIG. 2.

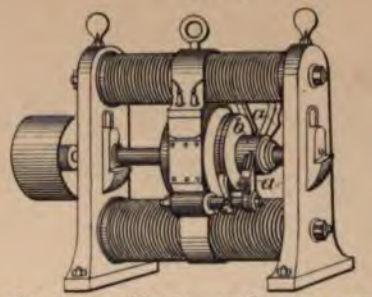
GRAMME CORE WITH A FEW COILS WOUND.

FIG. 3.



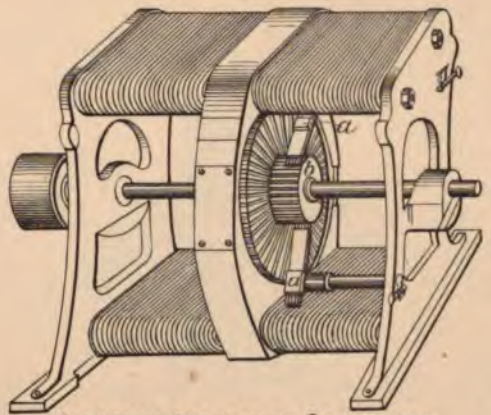
GRAMME BOBBIN COMPLETE.

FIG. 4.



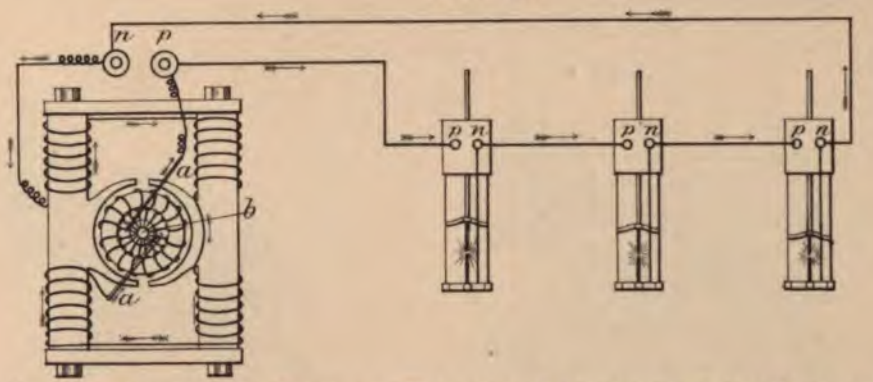
A. GRAMME MACHINE COMPLETE.

FIG. 5.



B. GRAMME MACHINE COMPLETE.

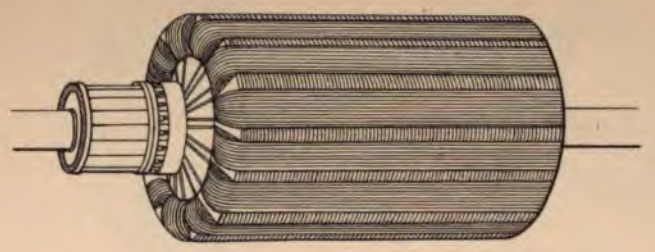
FIG. 6.



SHEWING PASSAGE OF CURRENT THROUGH ARMATURE FIELD MAGNETS LEADS AND LAMPS.

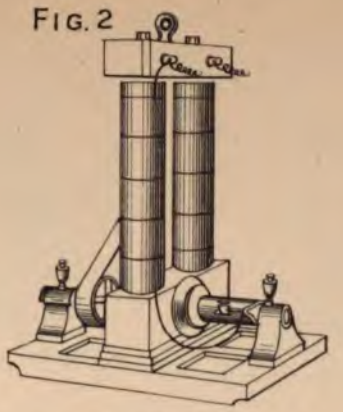
To illustrate Mr. Sydney F. Walker's paper "On the Principles of Electric Lighting."

FIG. 1



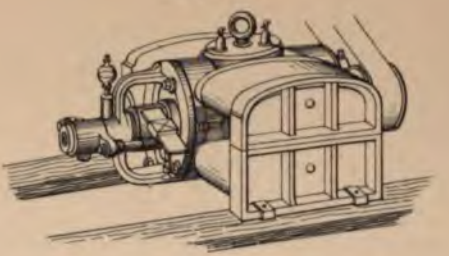
LUMLEY BOBBIN COMPLETE.

FIG. 2



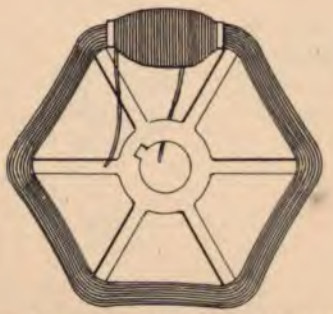
THE EDISON MACHINE.

FIG. 3.



BÜRGIN MACHINE COMPLETE.

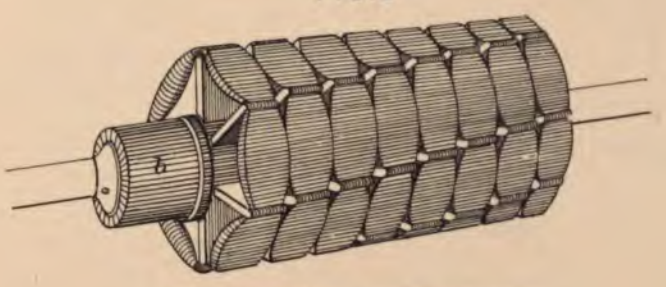
FIG. 4



SINGLE RING OF BÜRGIN ARMATURE WITH ONE COIL WOUND.

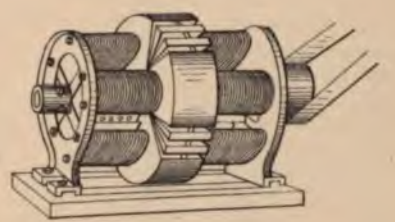
Proceedings N.E.I. of M. & M.E. 1884-85

FIG. 5



BÜRGIN BOBBIN COMPLETE.

FIG. 6



THE GÜLCHER MACHINE.

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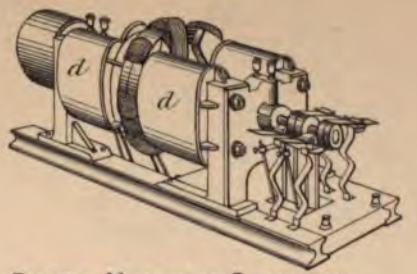
To illustrate Mr. Sydney F. Walker's paper "On the Principles of Electric Lighting".

FIG. 1.

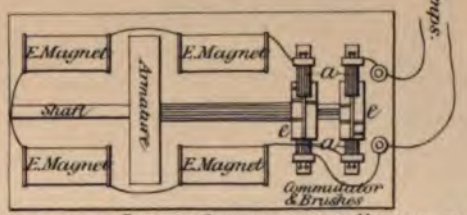
BRUSH ARMATURE.

FIG. 2.



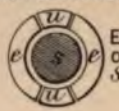
BRUSH MACHINE COMPLETE.

FIG. 4.



BRUSH COMMUTATOR ON SHAFT & CONNECTIONS TO MAGNETS OF MACHINE.

FIG. 5.

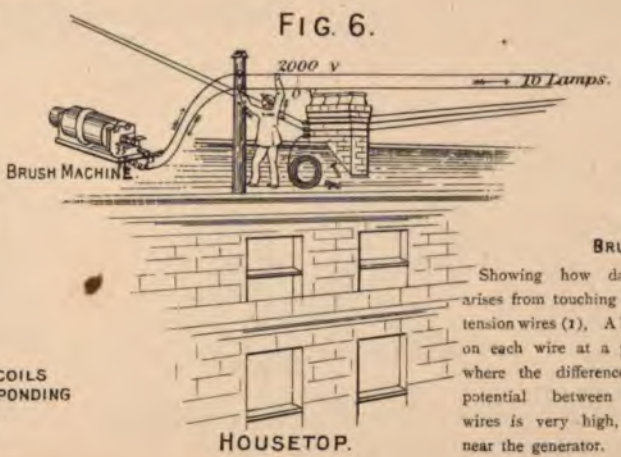


END VIEW OF ONE RING OF BRUSH COMMUTATOR, *S* IS THE SPINDLE.

FIG. 3.

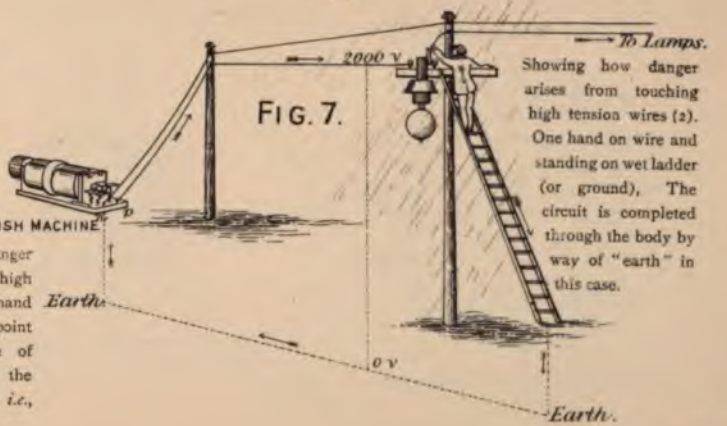
CONNECTIONS OF ONE SET OF COILS ON BRUSH ARMATURE TO CORRESPONDING RING ON COMMUTATOR.

FIG. 6.



Showing how danger arises from touching high tension wires (1), A hand on each wire at a point where the difference of potential between the wires is very high, *i.e.*, near the generator.

FIG. 7.



Showing how danger arises from touching high tension wires (2). One hand on wire and standing on wet ladder (or ground), The circuit is completed through the body by way of "earth" in this case.

Proceedings N° E.I of M&M.E. 1884-85

Anst Photo Engraving Co

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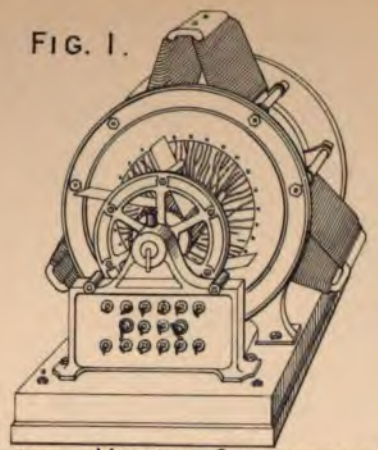
To illustrate Mr. Sydney F. Walker's paper "On the Principles of Electric Lighting."

FIG. 1.



ELPHINSTONE – VINCENT CONTINUOUS CURRENT DYNAMO-ELECTRIC MACHINE.

FIG. 2.

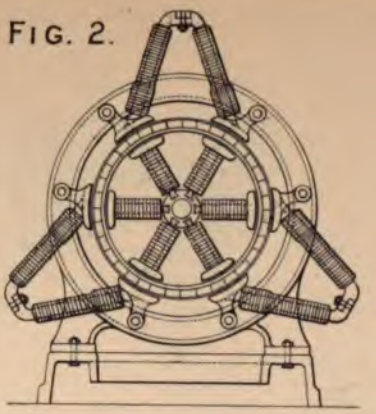
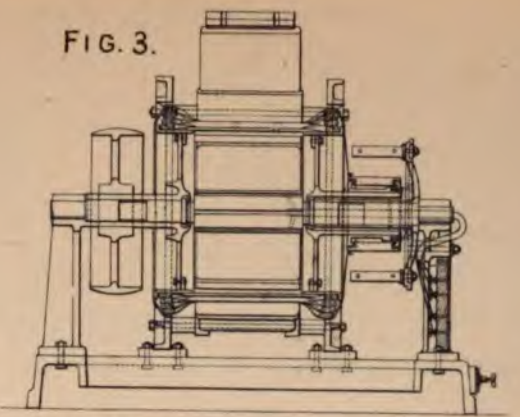


FIG. 3.

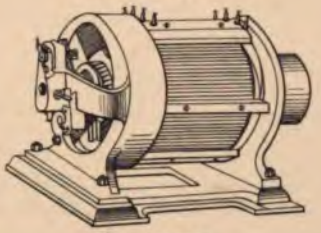


ELPHINSTONE-VINCENT MACHINE.

FIG. 4.

DE MERITENS MACHINE.

FIG. 5



GRAMME ALTERNATING-CURRENT MACHINE.

FIG. 6.

SIEMENS ALTERNATING-CURRENT MACHINE COMPLETE.

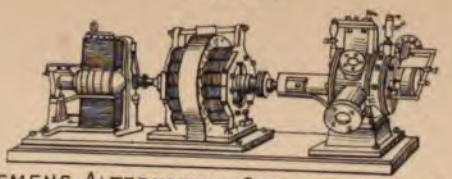
FIG. 7.

FERRANTI-THOMPSON ARMATURE.

FIG. 1.

FERRANTI-THOMPSON MACHINE COMPLETE.

FIG. 2.



SIEMENS ALTERNATING-CURRENT MACHINE WITH EXCITOR AND ENGINE ON ONE SPINDLE.

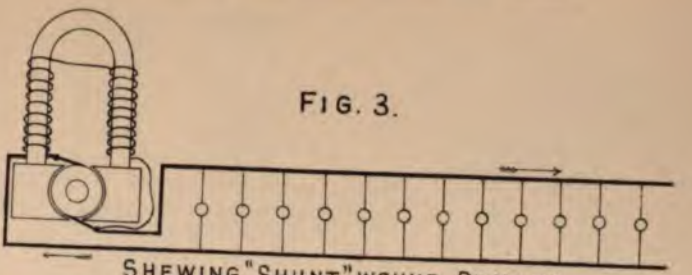
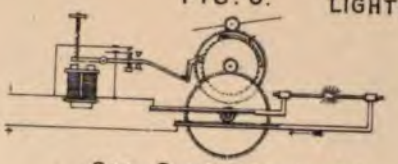


FIG. 3.

SHEWING "SHUNT" WOUND DYNAMO, LIGHTING 1 PARALLEL OF INCANDESCENT LAMPS.

FIG. 6.



OLD SIEMENS LAMP.

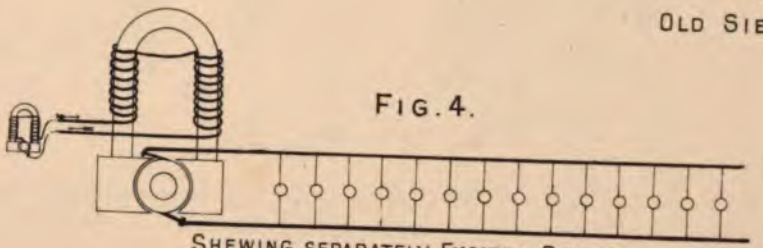


FIG. 4.

SHEWING SEPARATELY EXCITED DYNAMO, LIGHTING 1 PARALLEL OF INCANDESCENT LAMPS.

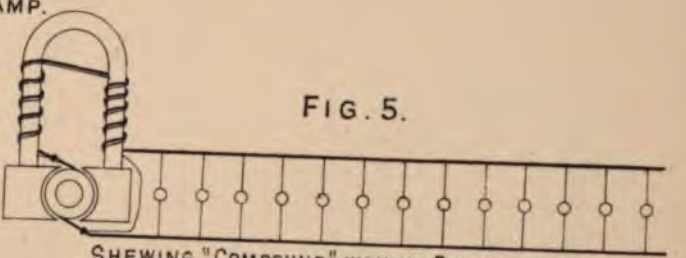
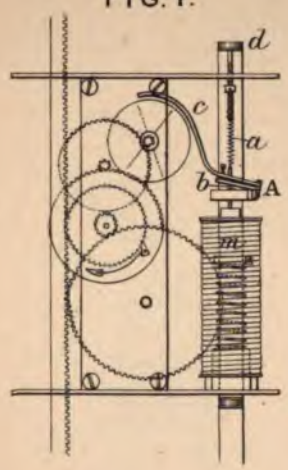


FIG. 5.

SHEWING "COMPOUND" WOUND DYNAMO, THAT IS WITH "SERIES" AND "SHUNT" WINDINGS COMBINED, LIGHTING 1 PARALLEL OF INCANDESCENT LAMPS.

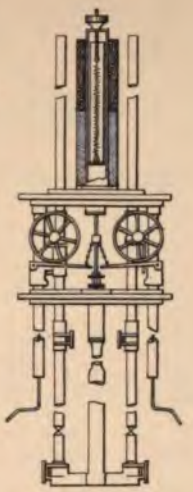
To illustrate Mr. Sydney F. Walker's paper "On the Principles of Electric Lighting".

FIG. 1.



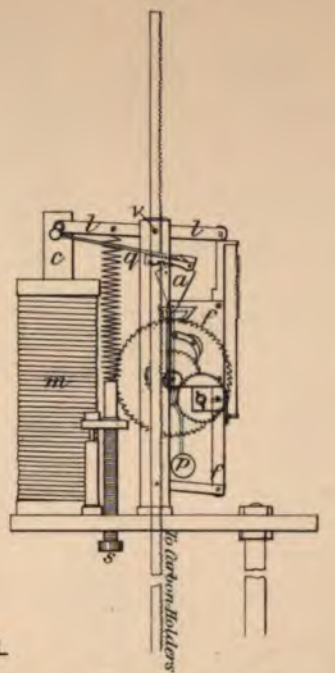
CROMPTON CLOCKWORK LAMP.

FIG. 2.



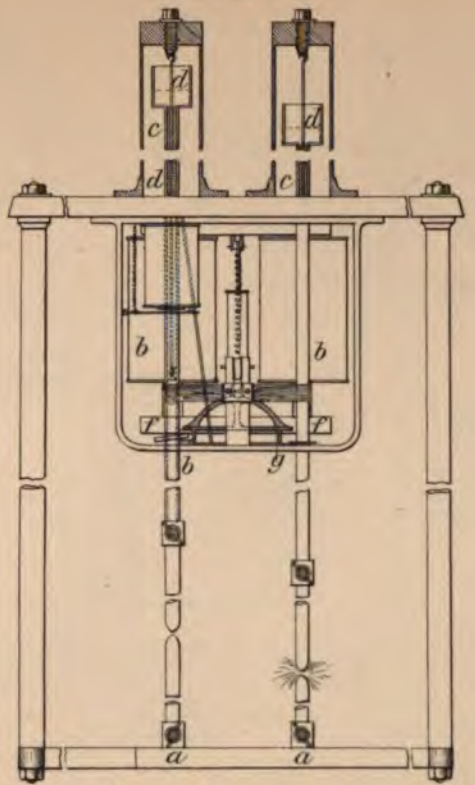
CROMPTON NEW DIFFERENTIAL ARC LAMP.

FIG. 3.



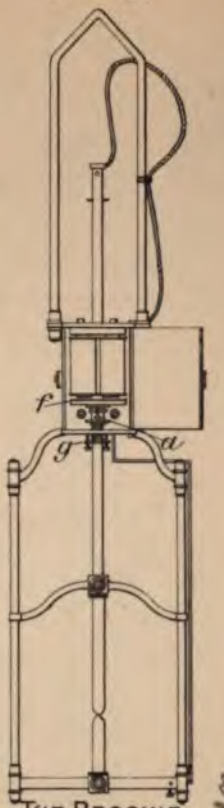
SIEMENS "PENDULUM" LAMP.

FIG. 4.



BRUSH ARC LAMP.

FIG. 5.

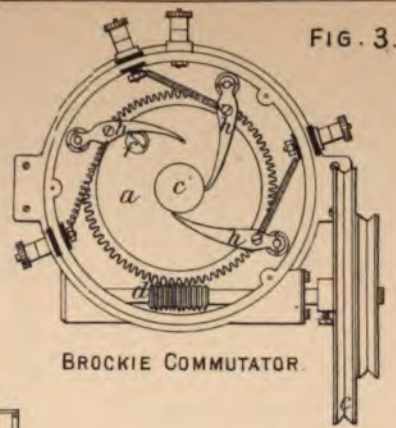


THE BROCKIE SINGLE ARC LAMP.

Proceedings N° E.I. of M.&M.E. 1884-85

To illustrate Mr. Sydney F. Walker's paper "On the Principles of Electric Lighting."

FIG. 3.



BROCKIE COMMUTATOR.

FIG. 4.

COVER FOR BROCKIE COMMUTATOR.

FIG. 5.

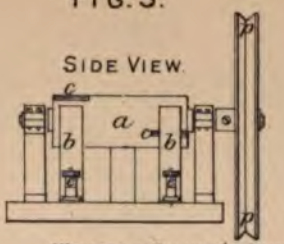
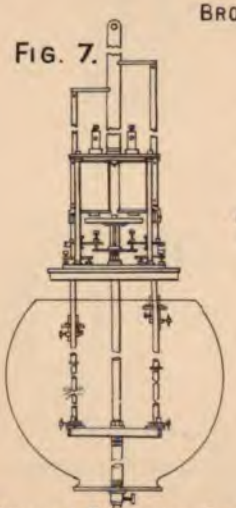


FIG. 6

WALKER & OLLIVER'S COMMUTATOR FOR BROCKIE LAMPS.

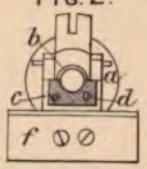
FIG. 7.



DOUBLE BROCKIE LAMP.

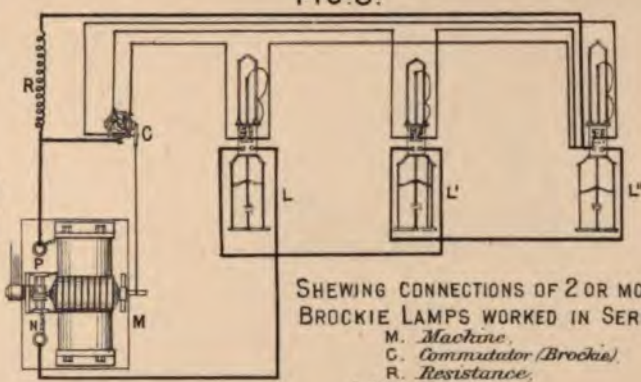
FIG. 1.

FIG. 2.



THE BROCKIE CLUTCH.

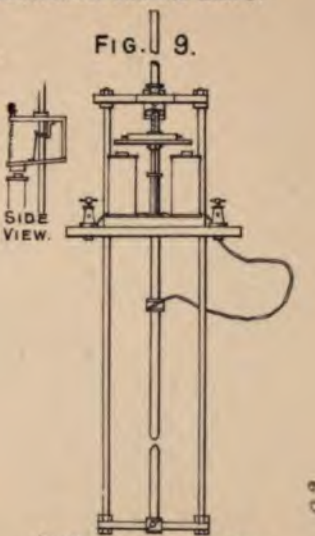
FIG. 8.



SHEWING CONNECTIONS OF 2 OR MORE BROCKIE LAMPS WORKED IN SERIES,

M. *Machine.*
C. *Commutator (Brockie).*
R. *Resistance.*
L. L. L''. *Lamps.*

FIG. 9.



LEVER'S ARC LAMP.

Proceedings No. 81 of Mech. E. 1884-85.

To illustrate Mr Sydney F. Walker's paper "On the Principles of Electric Lighting."

FIG. 1.

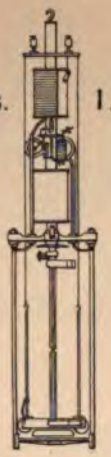
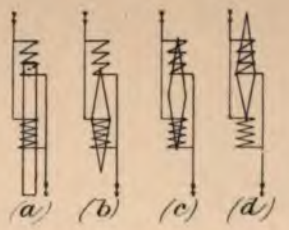
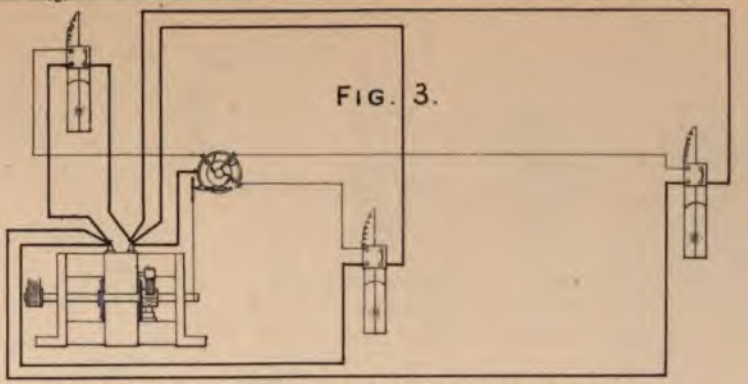


FIG. 2.



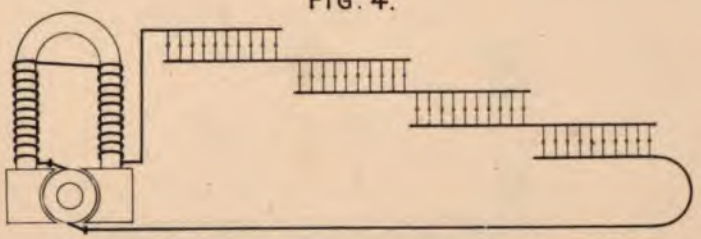
PILSEN LAMP, &c

FIG. 3.



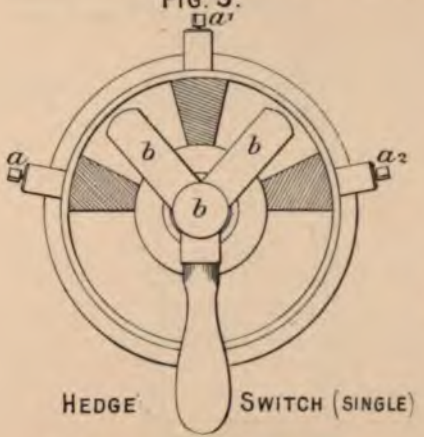
CONNECTIONS FOR BROCKIE LAMPS ON DERIVED CIRCUIT.

FIG. 4.



SHEWING "SERIES" WOUND DYNAMO, LIGHTING 4 PARALLELS OF INCANDESCENT LAMPS.

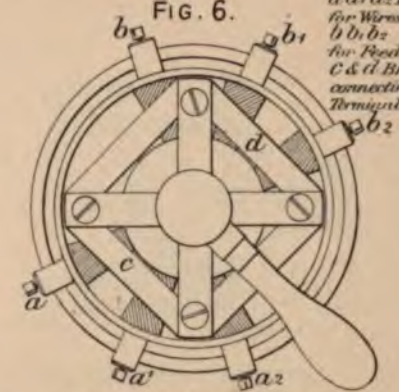
FIG. 5.



HEDGE SWITCH (SINGLE)

A A₁ A₂ Terminals for Wires
b b b Brass Lever connecting A & A₁ or A₁ & A₂

FIG. 6.



A A₁ A₂ Terminals for Wires
b b₁ b₂ do for Leeds
C & d Brass Arm connecting the var Terminals

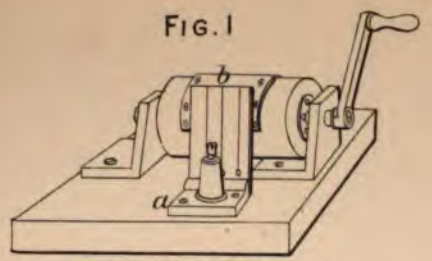
DOUBLE HEDGE SWITCH. FOR BROCKIE LAMP.

Proceedings N° E.I. of M&M.E. 1884-85

Vol. 7

To illustrate Mr. Sydney F. Walker's paper "On the Principles of Electric Lighting."

FIG. 1



THE DRUM SWITCH.

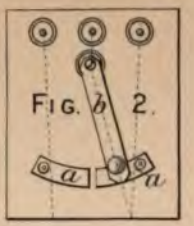
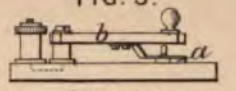


FIG. 3.



SWITCH.

FIG. 4

FIG. 5

SWITCH FOR A SINGLE LAMP.

FIG. 6.

SWAN HOLDER AND SWITCH COMBINED.

FIG. 7.

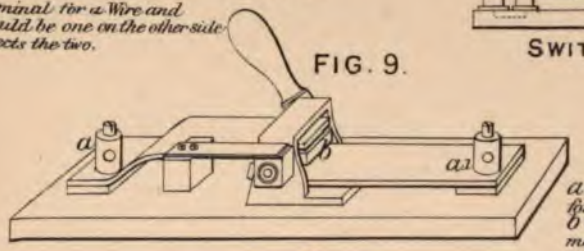
PLAIN SWAN HOLDER.

FIG. 8.

PLAIN SWAN HOLDER.

is Terminal for a Wire and ere would be one on the other side Connects the two.

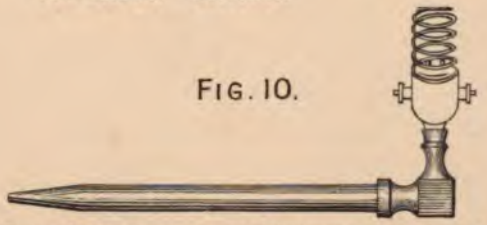
FIG. 9.



a & a1 Are Terminals for Wires. O a movable piece of Brass which may connect or disconnect them.

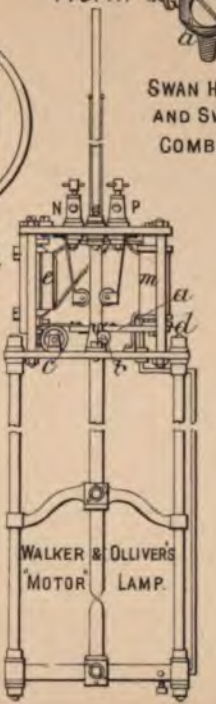
PATERSON SWITCH.

FIG. 10.



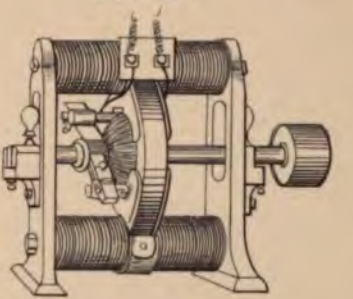
PLAIN IRON BRACKET FOR INCANDESCENT LAMPS.

FIG. 11.



WALKER & OLLIVER'S "MOTOR" LAMP.

FIG. 12.



THE SCHUCKERT MACHINE.

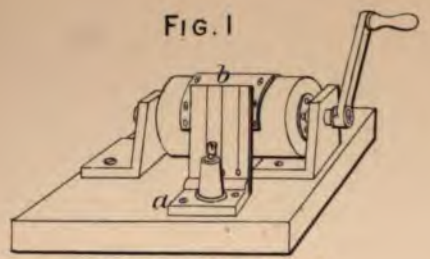
Proceedings N° E.I. of Mx.M.E. 1884-85

Imp. Brick Newcastle.

109.

To illustrate Mr. Sydney F. Walker's paper "On the Principles of Electric Lighting."

FIG. 1



THE DRUM SWITCH.

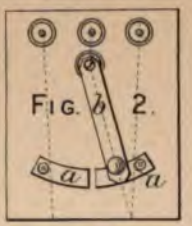
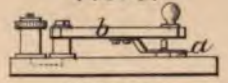


FIG. 2.

FIG. 3.



SWITCH.

FIG. 4

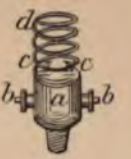
FIG. 5

SWITCH FOR A SINGLE LAMP.

FIG. 6.

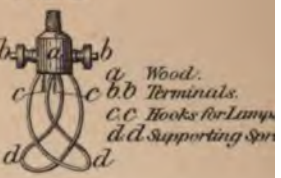
SWAN HOLDER AND SWITCH COMBINED.

FIG. 7.



PLAIN SWAN HOLDER.

FIG. 8.



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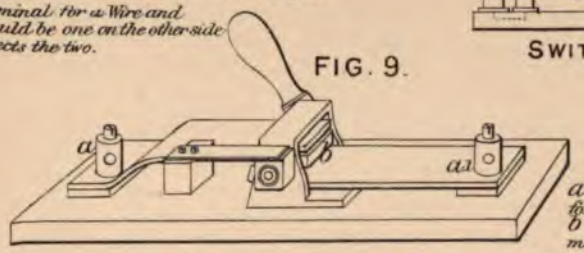

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PATERSON SWITCH.

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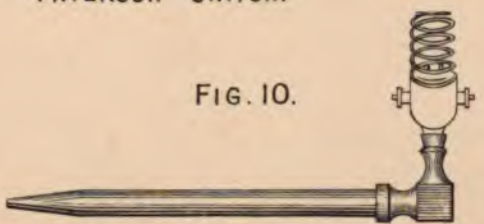


PLAIN IRON BRACKET FOR INCANDESCENT LAMPS.

FIG. 11.

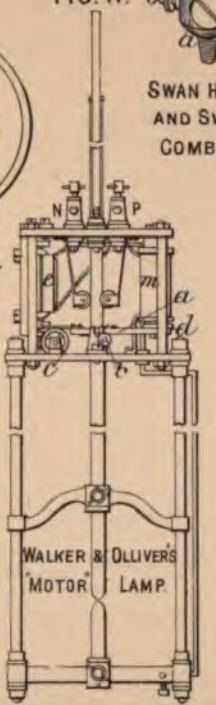
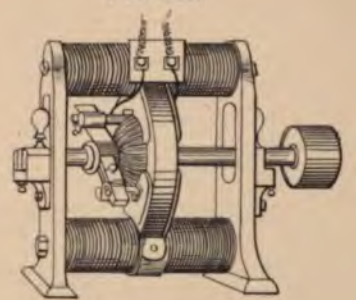


FIG. 12.



THE SCHUCKERT MACHINE.

Proceedings N° E.I of M&M.E. 1884-85

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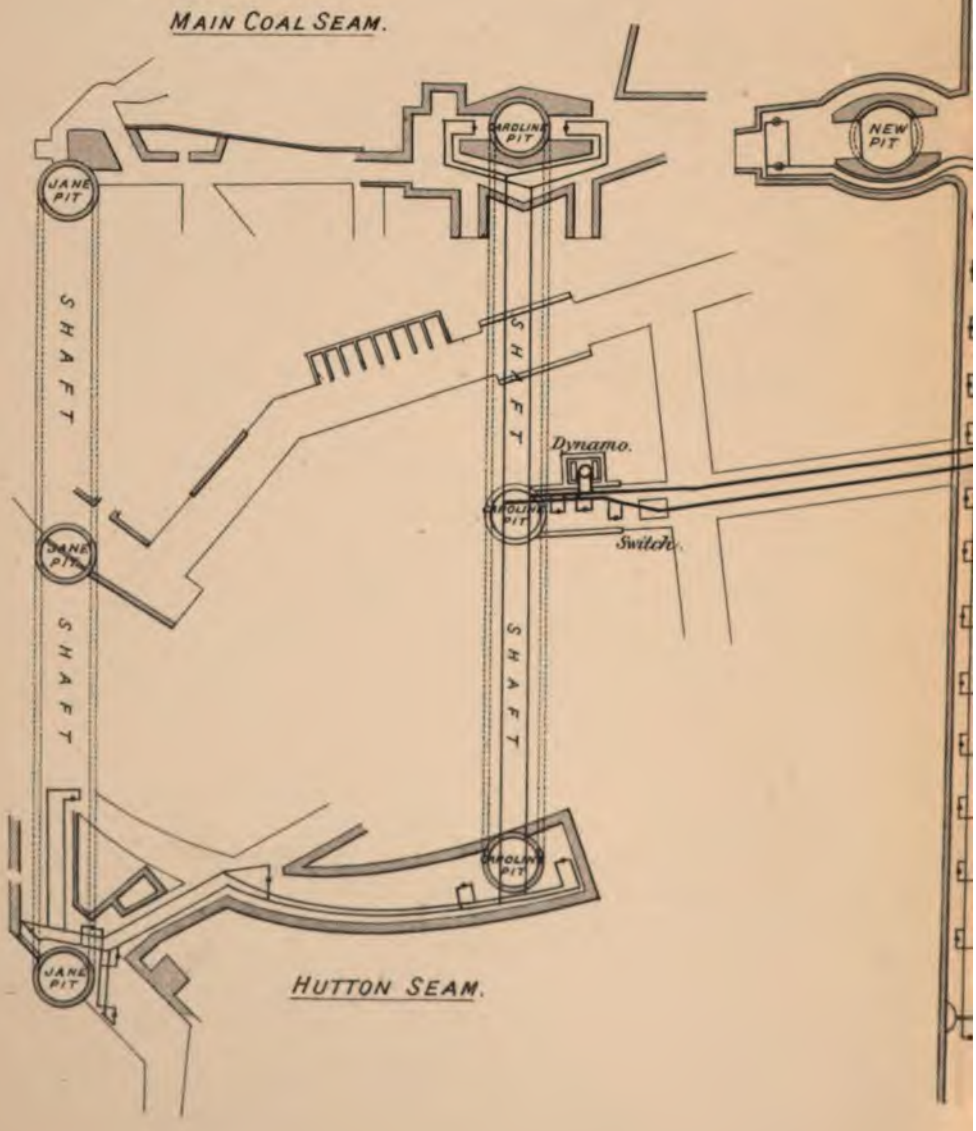
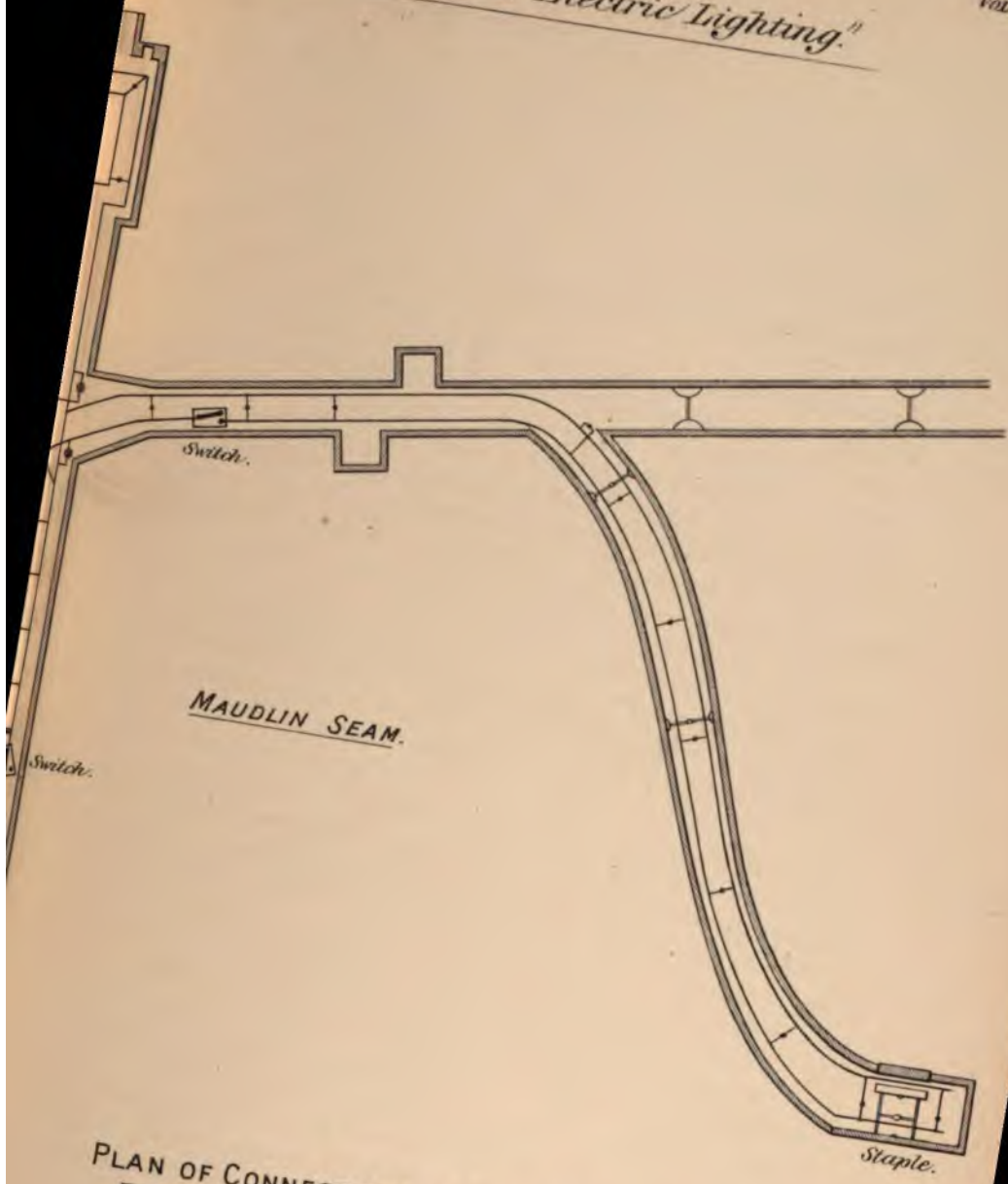
To illustrate Mr Sydney F. Walker's pa



Trans. N.E.I. of M. & M.E. 1894-95



PLAN OF CONNECTIONS OF THE INCANDESCENT ELECTRIC LIGHTS AT EPPLETON COLLIERY.

FENCE HOUSES.

lator. Work is done in storing electrical, or rather chemical, energy, just as work is done in raising the body of water in the hydraulic accumulator. The apparatus upon which the work is done will, in each case, give back a part of the energy that has been expended on them.

In the electrical accumulator there is, at starting, a perfectly neutral galvanic battery—a battery, in fact, from which, in its then condition, no current can be obtained. It consists usually of lead plates immersed in dilute sulphuric acid.

In the later forms, the lead has in some cases been covered mechanically with a substance that will facilitate the chemical re-actions that go on during charging, and thereby lessen the time required for storage. In the latest form, which goes by the name of Faure-Sellon-Volkmar, the plates are perforated, and the substance, red lead, which is to assist the action of the external current in charging, is pressed into these holes. Whatever the form may be, storage, or charging as it is called, is effected by causing a current of electricity from an external source to pass through the battery. Immediately a new set of conditions is set up. By the well-known laws of electrolysis, oxygen is set free where the current enters the battery and hydrogen where it leaves it. The oxygen forms with the lead, or the compound containing lead, a high oxide, while the hydrogen precipitates from the compound on the other plate, when it is used, pure *lead*.

There is now in lead and lead oxide in the presence of sulphuric acid, a powerful galvanic couple; and, as soon as the exciting current is removed, the battery will furnish a current in the opposite direction to that of the charging current, for as long, provided it be working properly, as any of the newly-formed elements of compounds remain to be acted on. In discharging, the chemical actions are reversed. The precipitated pure lead is now oxidized and the high oxide is reduced.

The inventors have met with great difficulties in perfecting the apparatus, as might be expected with a new thing, owing to various causes. The principal have been connections between the plates, caused by very beautiful but very troublesome lead trees growing across from plate to plate; buckling of the plates, owing to the alteration of their composition at different periods; expansion, etc.; falling out of the red lead between the plates, and so on; but most of these have now been overcome. Unfortunately two objectionable features remain, their great expense and great weight. They are destined, the writer hopes and believes, to have a great future in days to come, in utilizing the surplus

power of engines, the margin of variation, etc.; and in enabling irregularly running engines that have a margin of power to be used for the generation of electric currents.

At present, their principal and almost only use is, to steady the current furnished by a dynamo where a gas engine is used; and for the lighting, by night, of isolated installations, such as country houses, so that the engine may be stopped at a certain hour.

There have also been a few cases where a smaller engine, working both day and night, assisted at night by the accumulators it had charged during the day, has done work that would have required a very much larger engine to have done by itself. These would, however, be special cases. The writer has not, up to the present, met a case where the cost of a separate engine would not be less than that of accumulators; more particularly in those cases where counter shafting would have to be employed to deliver the power to the dynamo.

Mr. LAWRENCE asked what amount of the power given out by the dynamo was utilized in the lamps?

Mr. WALKER said the point raised by Mr. Lawrence depended entirely upon the construction of the apparatus. It was usually reckoned that the percentage lost in the dynamo was 10 per cent., that was the percentage lost in what he called electrical efficiency—lost altogether, as it was not seen in the electric current. If they put 100 horse-power on, they had 90 horse-power in the current and the difference was spent in the generator. The amount lost in the wires of the generator was not more than from 5 to 7 per cent., in extreme cases it might be 10 per cent., so that there would be left 80 per cent. of useful effect.

Mr. G. B. FORSTER had much pleasure in proposing a vote of thanks to Mr. Walker for his able and interesting paper. Though the progress of electric lighting had not been so great as they expected it to be two or three years ago, still there was no doubt it had made considerable progress, and was making progress every day; and this was owing to the work of such men as Mr. Walker, who were bringing it to that perfection which was required before it could come into general use. No doubt in many collieries it was a great benefit, especially where great screening operations were required, and in underground works. If the installation of the electric light was put up at the first, he believed it would be as cheap, if not cheaper, than gas.

Professor LEBOUR seconded the vote of thanks, and suggested that should the apparatus be again placed on the table when the discussion of the paper took place, much interest would be added if arrangements were made to light the incandescent lamps.

The PRESIDENT said he was sure they would all cordially agree with the vote of thanks to Mr. Walker. Although electric lighting had not yet come into general operation in collieries, still electric signalling, which depended very much on the same principles, was now very much used. He believed, in all cases where the electric light had been adopted, much of the success depended upon its first installation being effectually done. They might, from the paper, judge of the intricacies of the subject. As mining engineers they could not be expected to understand all about it, but they would benefit from having such a paper before them. Those who had the actual management of electric lighting and signalling, even the workmen themselves, were obliged to have some small knowledge of the principles of electricity, and much of the success depended upon having men in charge with a certain amount of this knowledge.

Mr. WALKER said he was much obliged for the kind way in which they had received the proposal of a vote of thanks. It had given him great pleasure to read the paper. He realized the truth of what had been pointed out, that the success of the work depended very much upon people having a knowledge of it.

The meeting then concluded.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, DECEMBER 13TH, 1884, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

JOHN DAGLISH, ESQ., PRESIDENT, IN THE CHAIR.

THE SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated :—

ASSOCIATE MEMBER—

MR. F. L. G. SIMPSON, Pease's West Collieries, Crook, by Darlington.

STUDENT—

Mr. R. A. S. REDMAYNE, Hetton Collieries, near Fence Houses.

The following gentlemen were nominated for election :—

ORDINARY MEMBER—

Mr. JAS. STEVENS, M.E., Kaiping Mines, c/o H.B.M.'s Consulate, Tientsin, North China.

STUDENTS—

Mr. ROBT. RUTHERFORD, South Derwent Colliery, Annfield Plain, Lintz Green.

Mr. FREDERICK GEO. HOOPER, South Derwent Colliery, Annfield Plain, Lintz Green.

MR. THOMAS YEOMAN, Loftus Mines, Loftus-in-Cleveland.

The following "Notes on the Coal-fields and Coal-mining Operations in North Formosa, China," by Mr. David Tyzack, were read :—

NOTES ON THE COAL-FIELDS AND COAL-MINING OPERATIONS IN NORTH FORMOSA (CHINA).

BY DAVID TYZACK.

THE writer having been entrusted by Sir Robt. Hart, Inspector General of the Chinese Imperial Maritime Customs, on behalf of the Viceroy of Fohkien, to examine and note the general outline, practical geology, and appearance of the coal-producing districts in the island of Formosa, landed in the port of Tamsui, on the north-west coast of the island, in the early part of 1875, for the purpose of developing the same. The town of Tamsui lies about one mile inland from the river bar, and consists mostly of a straggling town built partly of brick, with tile roofs; and largely of bamboo houses with grass-thatched roofs. The population of this town will not exceed 20,000. The trade of the port is mostly in tea, camphor-wood, indigo, sugar, and coals in small quantities from the native adit mines. On either side of the entrance to the port of Tamsui stands a high, conical, and picturesque range of porphyritic peaks, clothed to the very summit with dense jungle and grass 8 or 10 feet high. The two sentinel hills are respectively 2,800 feet high on the north side, and 1,720 feet high on the south. The Tamsui river is here about one mile wide at high water, but at low water several mud flats render navigation, except to small craft, risky. The precipitous nature of the hills, the dense jungle, rank vegetation, and absence of roads, render it difficult to penetrate up country except by navigating the various branches of the Tamsui river in flat-bottomed boats.

ASPECT OF THE COUNTRY.

The general appearance of this northern part of Formosa, a few miles from the west coast, may be likened to that of an immense saw with the teeth upwards, the sharp peaks turned to the north, and the slopes to the south, the angle of the slopes varying from 15° to 45°, and the escarp-

ments so precipitous that it is generally impossible to climb them. As this peculiar uniformity of configuration not only affects the surface but is carried beneath to the rock formation, it will be readily understood that this part of Formosa presents to the geologist a simple index, as he travels north or south, of the succession of the different rock-beds upwards or downwards.

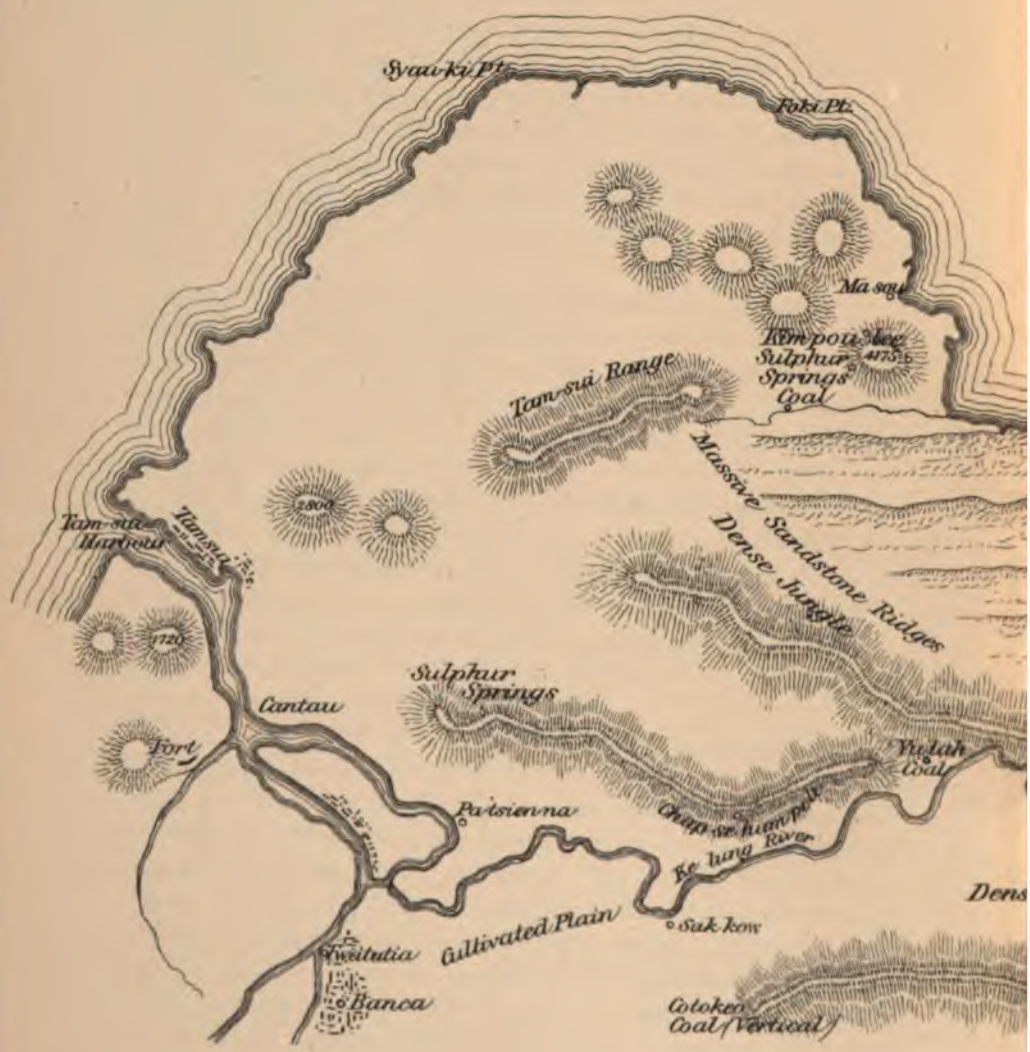
Leaving Tamsui and sailing eastward, the country passed through is very beautiful, range after range of rugged and verdant hills succeeding each other; and if the fleecy clouds which usually screen the far distant view happen to be lifted by some passing breeze, the snow-capped peaks of some of the more central mountains are discerned, whose bases, surrounded with primeval forest, are accessible only to the native savage. The settlement of Twatutia, a suburb of the city of Banca, is soon reached. Here, at Twatutia, there is a small colony of English merchants who carry on an extensive business with the native Chinese in tea, camphor, opium, sugar, coal, etc., and who have also charge of extensive tea-firing works.

Banca itself is an important city, about twelve miles from the river mouth, holding the same relation to Tamsui as Newcastle does to Shields. It lies between the Kelung river and the north bank of the Samquai branch, and is in fact at the junction of the three main river branches. As it is situated in the midst of a large alluvial and fertile plain, many of its inhabitants are well-to-do. The city is mostly built with bricks of excellent manufacture, many of the houses being ornamented with blue porphyry stone facings and pillars, which are well carved with various devices. The city has numerous and extensive shops where almost any article of European or American, as well as native produce, may be purchased. It is difficult to arrive at the population of a Chinese town, as no census is taken; but the population of Banca and neighbourhood may be taken at somewhere about 100,000.

The Tamsui river in this neighbourhood branches off into three widely-apart districts. The Tokaham river diverging to the south-west passes through some rough, mountainous, and almost impenetrable country to the Chinese town of Tokaham, where a small barter trade is carried on with the native Aborigines. The second branch of the Tamsui river leaving Banca is called the Samquai branch, which, after passing through richly-cultivated plains, penetrates to the south-east in the rugged hill country in possession of the Aborigines, where again barter is carried on between the natives and Chinese. The third river branch leaving Twatutia tends almost due east, and after many windings

To illustrate Mr D. Tyzack's paper "On the Formosa Coa

ENLARGED MAP OF THE EXTREME NORTHERN PART OF T



Nº E I of Mo M E 1884-85.

LAND.
Geographical Miles.
0 10 20 30 40 50
THE ISLAND OF FORMOSA.
Toki Pt.
Tamsui Har.
Kelung Har.
Petou Pt.
KOHALAN
Steep I.
Sawo Bay.
TAMSUI
CHANGWA
Wootse R.
ABORIGINAL
Mt Morrison
KIA-E
Tayowan
Port Hok a Kau
Tai wan foo
TAIWAN
FUNGSHAN
Samasana
Ta kau koro
Lamhay I.
Botel Tobago
So. West Pt.
So. Cape
Brooker Pt.
Palm Isd.
Imaha Pt.
Richard Harbour
Petaou Coal Harb.
* Chinese Government Colliery
Coal Peak
Kelung
Fault Rise 100ft
Tuatsung
Quar-See Kaw Bay
Petou Pt.
Coal
Chimoque
Coal Pit Hatchong
Coal
Siouten
Keckekechungo
Titsuicoo
Nwan
Goomaisooa
Dense Jungle
2850
15
20 Geographical Miles.

and numerous shallow rapids, passes within two miles of the port and town of Kelung and enters the coal-field which had to be inspected. This branch of the river has largely assisted the development of coal-mining here, for without it no accessible road to the western sea-coast would exist.

For some distance up the Kelung branch of the Tamsui river, above Banca, fertile plains growing sugar, rice, corn, sweet potatoes, etc., are passed, and shortly afterwards a rugged, precipitous country is entered, through which the river winds and twists as it encounters one rocky obstacle after another in its passage towards the sea. The coal-bearing strata on the outskirts of the Kelung coal-field are then reached.

Throughout the journey the configuration of the hills and the parallelism of the rock-beds, one with the other, are very remarkable. The hills on the north side of the river slope regularly away to the south, but those to the south are precipitous, and it is evident they are the escarpments of gentler slopes southward : the height of these escarpments will vary from 300 to 800 feet. The rocks exposed to view consist for the most part of yellow, massive sandstones, blue shales, coarse shelly limestones, thin iron bands, and dark blue argillaceous shales containing nodules of ironstone.

The fossils which the author has been able to obtain are not numerous, but sufficiently characteristic to mark the geological epoch of the coal-beds of the district. Professor Lebour has been good enough to examine them, and has fixed their identity with those found in the Miocene formations of other countries.*

On account of the almost impassable nature of the country to the south of the Kelung river, the survey was not extended beyond a few miles south of that river in the neighbourhood of Kelung, but respecting the country from this point up to the sulphur springs of Kim-pou-lee, in the north point of the island, some passing remarks will be made. The general deductions arrived at may be briefly summed up as follows :—The upper portion of the Kelung river branch constitutes the trough of a synclinal axis (*a b*, Plate XII.) the hills to the north dipping south, and those to the south dipping north; on the southern side of the river, at no great distance, intrusive porphyritic hills break through the stratified rocks and rise to a height of 2,850 feet. The northern side of the river contains several beds of workable coal which crop out in succession as they approach the port of Kelung ; one seam only continues under the bed of the harbour and crops out a mile further north-west. The formation may

* Mr. Lebour's remarks will be found at page 81.

be fairly set down as Miocene, the fossils previously mentioned having been obtained from this series. Proceeding further north, immense heavy beds of red sandstone are found which may possibly be considered as upper and lower new red sandstone; but there seems to be no evidence of the existence of magnesian limestone. Still further north, at a distance of about ten miles from Kelung, another coal-bearing formation is found, which, with its sandstone, coal-beds, and shales, so closely resembles that in the north of England, that it may be considered as a part of the true carboniferous system. This must, however, be accepted as a theory and not as an ascertained fact, as circumstances would not permit the collection of the necessary fossils. As the inhabitants of this district were hostile to the introduction of coal-mining, all explorations had to be made under the protection of a guard of soldiers, and as the weather was very bad, the observations extended to generalities rather than to details.

Rising abruptly and breaking through the carboniferous system is a range of igneous porphyritic mountains over 4,000 feet high ; this range is noted for its extensive sulphur springs some 2,000 feet above the sea. A visit to these disclosed a number of huge caverns opening into the precipitous sides of the mountain, bellowing forth dense volumes of steam, evidently under considerable pressure, and charged with sulphurous smoke which shot out into the gorge. The noise created by these huge jets of steam was simply deafening, and could only be compared to the simultaneous blowing-off of innumerable steam boilers under very high pressure; in fact, it was impossible to hear anyone speak within several hundred feet of the blasts. This seemed to indicate that a very active heat-producing agency was at work below.

The evident fact of a system of coal-bearing strata, perhaps with numerous beds of coal abutting against intrusive igneous rocks, may possibly account for the heavy generation of steam and sulphur which is going on at these Kim-pou-lee sulphur springs. The object of visiting the springs was to ascertain for the Government authorities the possibility or otherwise of mining the deposit of sulphur which the Chinese supposed to exist here ; the conclusions arrived at not being satisfactory, the authorities were advised to abandon any attempt at exploring the district, but they still persisted in the possibility of driving a drift into the mountain side in order to secure the sulphur. Against all remonstrances they commenced a drift which they continued for several months. The inevitable result followed : they holed the level into one of the active blowers of the springs which immediately suffocated the workmen, whose bodies still remain in the adit.

VISITS TO NATIVE MINES.

There is a large number of native mines or drifts scattered over the country, all within a radius of fifteen miles from the port of Kelung on the north-east coast, but the most important mines are those within six miles of Kelung.

The usual method employed by the natives in mining coal is to start in a drift at the lowest possible level of the hill, either in the stone or coal, as a water level and exit for their coals; these stone drifts are seldom above forty or fifty yards long before reaching the coal. This work is all done with the pick, with which the natives are very expert. These adits or drifts are about 3 feet 6 inches high by 2 to 3 feet wide. On account of the steep slopes and deep gullies from which the above drifts enter the hills, a heavy cover immediately puts on to their coal workings, often several hundred feet thick in a few yards; this heavy cover frequently prevents them from having any more than the one entrance to their coal, and is, therefore, a great stop to extensive working, as in such a warm climate the ventilation is defective and for months together it is impossible to enter the drifts till the cold N.E. monsoon sets in. In a few of the native mines the hills are pierced through from one valley to another, in some instances for a distance of three-quarters of a mile. In such cases a good mine will turn out from twenty to twenty-five tons per day. The mode of working is usually to drive narrow places about four feet wide every two or three yards, thus leaving square pillars the same size; the rise places are driven direct to the rise. Attempts are made after reaching their limit of working to reduce or rob these pillars, but the consequence is frequently a collapse of the mine.

The means in use to bring the coal from the face to the day are very rude, and consist of a basket 3 feet 6 inches long, by 1 foot 6 inches wide, by 1 foot 2 inches high, which is placed upon a frame, or tram, fitted with two wooden rollers; this is dragged along planks placed lengthwise in a narrow cutting in the soft thill. The number of these baskets filled per day (a day commencing at 8 a.m. and finishing at 4 p.m.) is from eight to nine per man, which would give the amount wrought by each man to be about 30 cwts.; for such a day's work a man receives 1s. 8d., and the putter engaged to extract the same amount receives 1s. Most of the coals mined near Kelung are carried to that port in baskets by coolies over the steep precipitous hills, up and down steps cut in the rocks, for a distance of two, three, or even four miles. The labour attending this in the hot weather is painful to witness. Thousands of

men were engaged in such work, but when the new Government coal-mines were opened out, a small railway was constructed which did away with a large amount of this painful labour.

The following Table will give an idea of the thickness of the coal-seams worked by the natives, and the dip of the strata about Kelung.

Name of Mine.	Thickness of Seam. Ft. In.	Dip of Strata per yard. In.	Remarks.
Tit-sui-coot	3 5	... 9 ...	Dip, South.
Chim-oh-tor	2 9	... 9 ...	„ S. 20° E.
Keck-e-ke-chungo ...	2 6	... 8 ...	„ N. 20° W.
Se-ca-tien	3 0	... 6 ...	„ N. 20° W.
Chim-o-que	3 4	... 6 ...	„ S. 45° E.
Yu-lah	1 7	... 12 ...	„ S. 25° E.
Chap-se-hum-pe-li ...	3 4	... 36 ...	„ S. 30° E.
Cotokeo	4 6 coal	... vertical ...	Band 2 ft. 6 in.
Luk-tion-lui	2 6	... 20¾ ...	Dip, South.
Nwan Nwan	3 6	... 12 ...	„ „
Goo-mai-sooa	3 6	... 12 ...	„ „
Tae-kow-chew	3 3	... 8 ...	„ S. 50° E.
Tua-te-cung	3 0	... 9½ ...	„ S. 45° E.

From the very broken nature of the country, with its numerous faults and natural denudations, it is extremely difficult to connect one seam with another, but experience points to the existence of four distinct seams of coal in the Kelung coal-field, viz.:—

No.		Ft.	In.	
1	=	4	6	of coal.
2	=	3	5	„
3	=	2	6	„
4	=	1	7	„
Total	=	12	0	„

The area of the Kelung coal-field will not exceed eight square miles, but on account of faults and denudations, the rapid dip of the coal, and the inroads made by native mining, the available coal which may yet be worked cannot be estimated at more than from twelve to fifteen millions of tons. Most of the coal which it was possible to win by means of water-levels has been worked for many years by the Chinese, consequently the "hill-mined" coal may be said to be approaching exhaustion. It will, therefore, be necessary to use engine-power to win what coal yet remains to the dip in this field.

Before leaving the subject of available coal in the Kelung coal-field it may be as well to mention that outside of this district other valuable seams of coal of greater thickness are known to exist, and under much

better conditions for working, but as they have been little explored and do not properly belong to the Kelung coal-field they do not come under the present notice.

The native Chinese population in the north of Formosa are quiet, steady, docile, and hard-working people, and friendly to Europeans, who may roam over the country without molestation; indeed the native Chinese are so hospitable that in passing their dwellings it is difficult to withstand their kindly invitations to partake of tea, rice, or the friendly pipe of tobacco, which are invariably offered. It is perhaps not generally known that the island of Formosa is in possession of the Chinese only round part of the east, north, and west coast, and that the interior and east and south coasts are in possession of savage Aborigines. These latter people and the Chinese on the debatable or border-land of separation are in a continual state of feud, and much blood is spilt and many lives are continually lost on both sides. The great bone of contention is the demand for camphor-wood which the primeval forests of central Formosa furnish in large quantities. The Chinese on the frontier of the savage country obtain by means of bartering such articles as knives, gingalls, cloth, pigs, etc., the privilege of cutting down camphor trees on certain defined hills, but, as they frequently overstep the bounds marked out, constant feuds arise, and it is a common occurrence for their stockades to be assailed and lives lost.

This digression might appear out of place here were it not that several hundred men from one of the semi-savage tribes of the east coast, who were friendly with the Chinese in that district, had to be employed in the Government mine, and to their credit it may be said that they were hardy, robust, and eager workers, employed for the most part as hand-putters, or at other rough work, underground.

The survey of the Kelung coal-field being finished and the report matured, it was necessary to repair to the city of Taiwanfoo, the capital of Formosa, in the south of the island, and there lay the scheme before some of the high officials for their approval and sanction. The plans embraced the sinking of shafts, the laying of railways to the sea, the use of engine power, pumps, etc., etc. The railway idea highly pleased the officials; the hauling, winding, and pumping, they silently agreed to as it was beyond their experience; but the suggestion to make a large hole down into the bowels of the Island of Formosa was against their creed. Several days were spent discussing the effect of the deep hole it was proposed to make; one official objected on the score that this hole would destroy the Feng-shui (good luck) of the Island, and enrage the Evil

Spirit of the earth, which would stalk forth and breathe pestilence over the land. Another official wished to know if the effect of an earth-shock would not cause the sides of the shaft to crumble in and bury all the underground workmen. But another startling suggestion of a high official will more clearly show to what height their knowledge has reached. The question was gravely put and eagerly discussed by a number of old and middle-aged Mandarins of high rank, thus :—If this proposed deep hole were sunk, would it not be possible to go too far, and so break through the bottom of the Island as to allow the water to rush up the shaft and cause the Island, with all its inhabitants, to sink to the bottom and be drowned ? Such questions, however, were in the end satisfactorily answered by pointing out that there were many such deep holes in England, which Island was yet floating satisfactorily. All scruples being satisfied and funds voted, the necessary machinery was purchased in England and a North of England mining staff engaged. After a few trial borings were made, a 14 feet diameter shaft, which was the first work of the kind ever executed in China by Europeans, was commenced in October, 1876, and in April, 1877, the main coal was reached at a depth of 45 fathoms; good, clean bituminous steam coal, 3 feet 5½ inches in thickness.

As a copy of the records of the strata passed through in sinking the shaft is not available, an account is given of the journal of a hole which was commenced on June 7th, 1876, at some distance to the rise of the main shaft:—

	Fs.	Ft.	In.	Fs.	Ft.	In.
Soil and clay ...	0	5	0			
Sandstone	3	4	6	4	3	6
COAL	0	0	10			
Sandstone	2	5	0			
Hard gritty stone...	0	3	0			
Freestone	1	0	8			
Hard gritty stone...	0	2	8			
Mild freestone ...	7	0	6			
Dark freestone ...	2	0	7			
Grey freestone ...	1	0	5	19	5	2
COAL	0	0	2			
Grey freestone ...	7	1	7			
Dark freestone ...	0	3	6			
Main Coal Seam—						
	Ft.	In.				
COAL ...	0	2				
COAL ...	2	10				
	0	3	0			

	Fs.	Ft.	In.	Fs.	Ft.	In
Freestone and clay	0	3	6			
Strong grey post ...	3	2	10			
Strong grey metal ..	0	2	11			
Grey post	1	1	9			
Grey metal ...	1	1	0			
Strong grey post ...	3	2	6			
Strong gritty stone	0	2	9			
Dark freestone ...	2	3	3			
Freestone, with dark partings ...	3	2	0			
Mild grey metal ...	5	0	0	49	5	11
COAL, mixed with clay	0	1	6			
Clay and grey metal	0	3	0			
Grey post	0	4	9			
White post, with partings... ...	2	3	9	54	0	11

A tramway, carrying trucks of two tons capacity, was by this time constructed and at work; a large heapstead was erected, with four double-barred screens and sidings for wagons; a powerful winding-engine and double cage were got to work; underground hauling engines followed—main and tail rope system; a Guibal ventilating fan was erected; steam saw-mills were put up; smith's and wagon shops were built; and the whole surface put into first-rate order similar to a large mining establishment in this country. A second shaft, about 300 yards from the first, was sunk for the purpose of ventilation, and a new fan was erected there, producing about 30,000 feet of air per minute.

The extensive underground workings were in the meantime won out to a sufficient extent to employ 300 hewers per day, and longwall working carried on successfully in one part of the mine, with pillar and stall in another. It was found that longwall working facilitated supervision of the workmen and produced more and better coals. On account of the heavy dip of the strata, 8 inches per yard, it was found necessary to drive all rise work cross-cut up the hill. Seven self-acting incline banks were worked to the rise, and two dip engine-ways brought the coals from the deep side; a treble ram pump, worked by an endless rope from an engine at bank, kept the dip workings free from water. By the above means between 60 and 65 scores of coals were eventually raised to bank daily, giving an average output when at full work of over 300 tons per day, the highest daily output having reached 360 tons.

All weights are calculated by the picul of 133⅓ lbs., and in May, 1882, the following were the prices current for coals at the port of Kelung:—

	Dollars.	s.	d.		s.	d.	
Best coal ...	... 23	... 99	8	per 100 piculs.	... 16	8	per ton.
Nuts ...	... 15·50	... 67	0	„	... 11	3	„
Dust ...	... 6·50	... 28	0	„	... 4	9	„

The hewing price was made dependent on the size of the coal. For instance, when 4 cwts. out of a tub containing 5·6 cwts. of coal would not pass a certain sized screen, the price was 14 cents. (7¼d.) per tub; but when more than 4 cwts. passed, the price was 6 cents. (3d.) only; and this was a powerful incentive to the men to make large coals.

Putting was 6 cents. (3d.) a tub, two men being required to each tub.

	Tons.
The output in the first 3 months of 1877 was	1,440
„ 12 months of 1878 was	16,016
„ „ 1879 „	30,046
„ „ 1880 „	41,236
„ „ 1881 „	54,000
„ „ 1882 „	74,010
	216,748

At this time the European staff left, and no further records are obtainable.

ANALYSES OF THE COAL BY MR. JOHN PATTINSON.

	No. 1. Per Cent.	No. 2. Per Cent.	No. 3. Per Cent.	No. 4. Per Cent.
Fixed carbon	44·19	46·40	47·83	48·08
Matters volatile at a red heat, other than sulphur and water...	44·80	43·40	44·07	42·19
Sulphur	·46	1·07	·45	·46
Ash	5·36	3·76	2·16	2·32
Water	5·19	5·37	5·49	6·95
	100·00	100·00	100·00	100·00
Calorific power, lbs. of water evaporated from 212° Fah. by 1 lb. of the coal, as determined in Thompson's calorimeter ...	lbs. 13·4	lbs. 13·6	lbs. 13·1	lbs. 13·4

The surface wagons from the pit ran a mile down to the sea by their own gravity, taking the hauling-engine rope with them; the hauling drum was fitted with clutches and attached to the main winding-engine when required, bringing up a set of empty wagons in five minutes; the wagons, on reaching the coal jetties, were tipped up on end by a self-acting balance and discharged their loads into lighters. The colliery coal jetties are three miles from the shipping berths in Kelung harbour.

The above is a brief summary of what has been accomplished at the Kelung Government Colliery, notwithstanding the immense difficulties which had to be overcome on account of the native prejudices and superstitions, and the official jealousies which were ever in the way to thwart the "foreign barbarians" from carrying out to a successful conclusion the work they had taken in hand.

One of the most trying difficulties in the prosecution of this work was the great mortality from fever, which in the months of July, August, and September, swept off regularly about 100 of the workmen; in the six years ending with 1882, close upon 700 men died from jungle fever on the works. As many of those men who died were being taught the various arts, such as smith-work, engine-fitting, handling of engines, ropes, wagons, inclined banks, pumps, putting and hewing, &c., it was difficult to supply a sufficient number of skilled men to carry on the work.

In conclusion, the author desires to state that, having been pressed to make these notes, it has afforded him pleasure to comply, in order that the record of the first advance in mining in the Empire of China, carried out by Europeans, may not be lost, and that this Institute may claim to have sent to far Cathay the first Mining pioneers.

The PRESIDENT said he was sure they had all listened to this paper with great pleasure, and he would now be glad to hear any remarks upon it.

Professor LEBOUR said he wished to make a few remarks with respect to the fossils which had been laid before him, and which enabled him to say that the rocks in which the coal was worked at Kelung in Formosa, were generally of the Miocene age. One set of the fossils consisted almost entirely of pectens, and Mr. Tyzack told him that quite a mass of rock was made up of this genus. The appearance of rocks of this sort would be the same as that of the marl-stone on the Yorkshire coast, where the rock was made up of pectens of an older date. Unfortunately, the genus pecten was not worth much to geological workers unless the specimens were perfect. The specimens exhibited were almost entirely natural casts. So far as these pectens were concerned this coal might be of oolitic or any later age. The last row of fossils, fortunately, contained some more useful specimens which enabled him to tell the age of the rock; they were flat sea-urchins which had never been known in rock earlier than the Tertiary age. Oddly enough, the same species had been found in the Miocene beds of France, India, Arabia, and China, and never in beds of any earlier age. There were a few other fossils of interest, but the point he had referred to made it appear, without doubt, that the rocks were of the Miocene age, although the general appearance of the rocks was oolitic.

Professor MERIVALE said the writer of the paper had referred to the great heat. Some information of the temperature of the workings might be of interest.

Mr. TYZACK said that in summer time the underground temperature was from 80 to 90 degrees, and on the surface the temperature in the shade was 10 degrees higher.

Mr. E. F. BOYD asked whether Mr. Tyzack was able to tell the usual sections of rock overlying the coal in Formosa. If he understood Mr. Tyzack aright, the coal was in valleys. Was he able to give all the

sections of rock—magnesian limestone, lias formation, and oolitic—continuous from the coals upwards? He himself had had the opportunity of seeing small deposits of coals in valleys near the head of the River Ayr, in Ayrshire, and near Loch Doon, on which occasion he accompanied the late Mr. Matthias Dunn who was called upon to report. He found it very much in the way Mr. Tyzack described, the porphyritic rock protruding in the aforesaid valley.

Mr. Tyzack had no doubt, but for breaks from troubles and faults, some of which were of great magnitude, there would be a complete succession of rocks; but in the particular instance where he had mentioned that the coal-seams were abutting against igneous formations, a large mass of mountains was thrown from the bottom up through the carboniferous system, and he could not trace on the other side any carboniferous layer at all. It was simply igneous at the north side entirely. The north point of the island was one igneous mass. Where he spoke of the sulphur springs there was a bed of coal five feet in thickness, which was exceedingly good and which abutted up against the igneous rock.

Mr. E. F. Boyd asked if Mr. Tyzack considered the sulphur to be a regular stratified sulphur rock, or was it deposited in the usual way?

Mr. Tyzack said there were enormous caverns in the side of the hill. The hill was porphyritic. The holes in the side of the hill had evidently in the first instance been small cracks, and the continuous rush of steam through them had increased their size until they were big enough for a locomotive and wagons to run in, and they were in some cases of considerable length. The sides, where the streams of steam issued, were covered with sulphur, probably with a considerable quantity of arsenic in it, but the principal thing was sulphur, and it was collected by the Chinese. A great portion of it was taken possession of by the Chinese Government for the purpose of making gunpowder. The water which came from below these blowers was distilled, and sulphur was got from it.

Mr. J. A. Ramsay said, Mr. Tyzack, in his paper, had shown that the physical condition of the coal was much what it was in North Bohemia. He (Mr. Ramsay) had just tried the coal and found that when burnt it had a slightly resinous perfume. This was one of the best proofs of the coal being of Miocene formation. He had never seen any fossils of the Miocene age in Austria so well developed or so hard as those shown by Mr. Tyzack. Indeed, in North Bohemia and in Austria generally, where the Miocene formation obtained, the sub-strata were so soft that they could be dug with a spade, blasting being hardly ever resorted to. The sub-strata varied very slightly, consisting of the usual diluvium and various

beds of semi-indurated clay, varying from a few feet to ninety or one hundred fathoms in thickness. There are two series of coal seams found in North Bohemia. The specimen shown resembles that of the lower series (Pech Kohle); but the Bohemian coal did not give such a correct line of cleavage, and the fracture of the sample looked almost like Welsh anthracite. The lower coal in Bohemia contains comparatively very little ash. There did not appear to be any ruling thickness for coal-seams in this formation; they were found in the Austrian dominions from a few inches to several hundred feet thick.

Mr. E. F. Boyd—Did the coal partake of the anthracite character?

Mr. Tyzack—The appearance of the seam of coal which abuts against the porphyritic rock is distinctly of the anthracite character. It is very similar to the Welsh coal.

A vote of thanks to Mr. Tyzack was proposed by the President, seconded by Mr. Ramsay, and unanimously agreed to.

NOTE ON SOME FOSSILS FROM NORTH FORMOSA, COLLECTED BY MR. DAVID TYZACK.

By Professor G. A. LEBOUR, M.A., F.G.S.

The small collection which the writer has examined is of great interest for many reasons, and especially because nothing, or next to nothing, has hitherto been recorded as to the palæontology of Formosa or the adjoining mainland.

It has, in the absence of publications on the subject, been found impossible to refer any of the mollusca represented to known species. They may, indeed, be specifically new and undescribed, though they are allied more or less closely to well-known types, and the genera to which they belong are in general clear and free from doubt.

The echinoid is well marked, and fortunately can, without hesitation, be referred to a well-defined species.

The fragment of a crustacean, on the other hand, though in a beautiful state of preservation is in itself insufficient to enable it to be satisfactorily named.

The following is a list of the organisms :—

1 and 2.—*Pecten*.—Two species. The larger of these seems to be the commonest shell of the rocks collected from, and the smaller appears to be far from rare. Both are closely allied to *Pecten Favrei*, D'Arch., and the smaller form may perhaps really be that species; but these fossils being natural casts and showing but little of the shell itself, it would be rash to dogmatize on the point. At first sight the rock, made up, as it is in places, of these pectens, bears a remarkable resemblance to some of the Liassic, so-called, marlstones, built up of not very dissimilar scallops and so well shown in the cliffs of the Yorkshire coasts.

3.—*Ostrea*.—One very fine specimen of a gigantic oblong species, distinguished by an abnormally prominent central base for the muscular attachment. Only the interior of both valves is visible.

4.—*Lutraria* (?).—A specimen represented by a natural cast only, and only partially exposed, but having the general form of this genus.

5.—*Cardium* (?).—Like the last, this is a natural cast and not fully exposed. Neither the umbones nor the hinges can be seen.

6, 7, 8.—Three other natural casts of bivalves allied to *Crassatella* and *Cytherea* in general form it is not possible more nearly to characterize.

9.—*Echinodiscus* (*Amphiope*) *bioculatus*, L. Ag.—This beautiful sea-urchin is the most interesting fossil in the series. It is represented by several specimens, and so good and perfect are they (though casts) that there can be no reasonable doubt as to the species. These scutellid urchins are the key to the age of the beds in which they are found. The group of perforated forms to which they belong is not known in rocks earlier than Tertiary, and the species is especially characteristic of Miocene deposits. Moreover, the same species (though of another variety) is found forming thin continuous bands among pecten-built rocks in India, which rocks, known as the Gaj series, are of Miocene age. The geographical range of this species in Mid-Tertiary times is very notable, since it is found in homotaxial and perhaps nearly contemporaneous beds in France, Arabia, India, and, as now appears, in China. Reference to the species will be found in Desmoulin's "Tableau Synonimique," p. 232, where it is classed as Var. B of *Scutella bioculata;* in L. Agassiz's "Monograph of the *Scutellidæ*," p. 73, Plate XI., Figs. 1-5; in Pictet's "Traité de Paléontologie," Ed. 2, Vol. IV., p. 222, Plate XCV.; and in the "Manual of the Geology of India," Vol. I., p. 463, Vol. II., Plate XVI.

10.—*E. bisperforatus.*—One specimen seems to represent this living species, but it is not so clear and distinct as the others.

11.—*Crustacean* fragment (?).—This beautiful but incomplete specimen is part of a crab's claw and when found was covered with perfectly preserved hair-like spines.

The following "Notes on the History of Mining in Cumberland and North Lancashire," by J. D. Kendall, C.E., F.G.S., were taken as read :—

NOTES ON THE HISTORY OF MINING IN CUMBERLAND AND NORTH LANCASHIRE.

By J. D. KENDALL, C.E., F.G.S.

THE position occupied by these counties in the mining world at the present day is such that the history of the development of their mineral resources is a matter of more than ordinary interest. Unfortunately, but as always happens when it is necessary to look far back into the past, the "first beginnings" are lost in the thickening haze of time, and even in the nearer prospect but a very imperfect view is obtained. Fortunately, however, in this case, the importance diminishes as the backward time increases, so that there is less reason than often exists for regretting the inability to open out the past. To write a complete history under these circumstances would be impossible, and to fill in the gaps, between points that may be somewhat distinctly observed in the prospect, by mere conjecture, although it might produce upon the whole a unifying and pleasing result, could not possibly produce a true picture. The writer will, therefore, in the main, confine himself to an outline delineation of those features which are most clearly discernible.

It is proposed to deal with the subject under three heads, viz. :—

1. Iron.
2. Coal.
3. Lead and copper, etc.

This arrangement is adopted mainly for the reason that it is the simplest, but also because it will keep separate references to operations which are in many respects different, owing to the marked dissimilarity there is generally in the form and nature of the deposits yielding the minerals included under each head.

IRON.

It is quite uncertain when the ores of this metal were first worked, but it can scarcely be doubted whenever this was, that the hæmatite veins of the Lake District mountains attracted attention before the more important deposits now being so extensively wrought in the Carboniferous rocks, for the simple reason that the mountain veins are so much more easily found, being in many cases quite easily seen on the surface. On the other hand the Carboniferous rocks are, generally speaking, obscured by a covering of glacial matter, which varies in thickness from a few

feet to more than 20 fathoms, so that the hæmatite deposits in them, even when not overlain by solid rock, would only be found by digging through the glacial deposits, an operation for which in early days, except where thin, there would be little need. Land drains would very seldom reach the solid rock, although they might do so occasionally. Pits, in which to bury domestic animals, and wells might also now and again pass through the superficial covering of sand, gravel, and clay, but as the proportion of hæmatite outcrops to the area of the rocks in which this mineral occurs is very small, most of these excavations would not prove ore. Still it is quite possible that some of them might. It is also possible that soft ore might be brought to the surface by the operations of burrowing animals, and so lead to a search being made for it. But in whatever way the mineral was found it is likely that its first use would be for colouring purposes, perhaps for marking sheep; the extraction of metals from it would follow when its nature and mode of occurrence became better understood.

The iron ore of Furness seems to have been known to the ancient Britons, for, a few years ago, whilst a drift was being made from the foot of a shaft at Stainton, one of the "old men's" workings was discovered, and within it, in front of a breast of ore, two polished stone celts of the usual type were found.*

Whether the Romans worked iron ore in these counties is not yet known, although it is very probable that they did, for at Lanchester, in Durham, extensive traces of their mining operations for iron ore, and also the remains of a wind furnace† have been found.

In nearly all the valleys of the Lake District there is indirect evidence of the early working of local iron ore. Heaps of iron slag occur by the side of almost every stream of any importance in the neighbourhood of iron ore. Some of these, the history of which is unknown, may be seen by the side of Whiteoak Beck, near Lowes Water; at the foot of Smithy Beck, Ennerdale; by the river Calder, near Thornholm; by the side of the Irt, near the Strands; and at the foot of Wastwater, as well as in Eskdale; whilst large numbers of them occur in High Furness. The fact of their being in these positions would seem to indicate that they belong to a period subsequent to that of the wind-furnace, or even its immediate successor, the furnace urged by hand-bellows or their equivalent, and that they may fairly be allocated to the time when, by the operation of that universal process in nature which secures the survival of the fittest,

* "Furness Past and Present," by G. M. Tweddel, 1876.

† "Roman Wall," second edition, 1853, by Rev. J. C. Bruce, M.A.

machines urged by manual labour gave place to more powerful machines impelled by water. This was the last stage passed through in the evolution of the means of blowing iron furnaces prior to the utilization of the steam-engine for that purpose; so that, although, as is well known, mechanical appliances of the ruder kind, like low biological forms, frequently persist through great lengths of time, yet it is quite possible that these slag heaps may not go so far back as do the written records to be hereafter noticed.

The earliest working of which any account seems to have been preserved was at Egremont, in Cumberland, or perhaps it would be more correct to say, in Egremont parish, for, as will hereafter appear, it is probable that Bigrigg was the place referred to. From the Chartulary of the Abbey of Holme Cultram, it appears that William, the third Earl of Albemarle, who died in 1179, gave to that abbey a forge at Wynefell (Whinfell), and an iron mine at Egremont. As mentioned above, this was probably at Bigrigg, in the parish of Egremont, and only about a mile from the town of that name. Iron ore is now being worked at Egremont, but it is under a considerable thickness of glacial drift, so that it is most unlikely any of it would be known in the twelfth century; but at Bigrigg the drift covering is, in places, very thin. Moreover it is certain that iron ore *was* worked in that locality at an early date, as will presently appear.

The next reference to early iron-mining is in the Chartulary of Furness Abbey.* The monks of that place must have wrought iron ore at Orgrave (midway between Dalton and Ireleth), in the early part of the thirteenth century, for it appears that in 1235 there was a dispute between Hamo de Orgrave and the Abbot respecting this ore. Roger de Orgrave was said to have conferred certain mineral rights upon the Abbot, which Hamo, son of the said Roger, disputed.

In 1282, or some subsequent year of the thirteenth century, the convent became possessed of the iron ore under Alinschales (Elliscales), and in the year 1400 they obtained a grant of the iron ore in 400 acres of land in Dalton, Orgrave, and Merton (Martin) It thus appears that some part of the valuable deposits which are now being worked in the localities just mentioned, were known at least 600 years ago.

In the reign of Edward II. (1307–1327), William de Lancaster, Lord of Kendal, made a grant of the iron ore at Plumpton to the priory of Conishead. The grant also included land whereon to build a forge, and the dead wood in Blawith for making charcoal.†

* "History and Antiquities of the Abbey of Furness," by Thos. Alcock Beck, 1844.

† Dugdale's "Monasticon," Vol. II., p. 425.

From Holingshed's Chronicles it appears that in 1317, in the reign of Edward II., the Scots, during one of their southerly incursions, "met with no iron worth their notice until they came to Furness, in Lancashire, where they seized all the manufactured iron they could find, and carried it off with the greatest joy, though so heavy of carriage, and preferred it to all other plunder."

Indirect evidence of the working of iron ore is obtained from the certificate of the revenues of Furness Abbey, by the commissioners of Henry VIII. in 1537. They say "there ys moche wood growing in Furneys Fells in the mounteynes there, as byrk, holey, asshe, ellers, lyng, lytell shorte okes, and other underwood, but no tymber of any valeue wherein the abbots of the same late monastery have been accustumed to have a smythey and sometyme two or thre, kept for making of yron to thuse of their monastery, and so now the said commyssyoners have letten unto William Sandes and John Sawrey as moche of the said woodes, that is to saye, of byrkes, ellers, hasells, old rotten trees, and other underwoodes, as will maynteyne iij. smytheys for the whiche they ar content and agreed to paye yerely to the Kinge's highness as longe as hit shall please his grace they shall occupye the same xx.li." These smithies were something more than the smithies of to-day, for they actually *made* the iron which they used, and doubtless made it from ore obtained in Low Furness.

Twenty-eight years after the above date, that is, in 1565, the smithies or bloomeries in the lordships of Hawkshead and Coulton were suppressed, because it was feared by the customary tenants of the said lordships, that the continuance of these smithies would cause a great scarcity of timber, as it was then being largely used for making charcoal, the fuel of the bloomeries. The £20 a year agreed to be paid by Sandes and Sawrey, as mentioned above, was arranged to be afterwards paid proportionally by the customary tenants of the lordships of Hawkshead and Coulton, and of other the lordships, lands, tenements, and hereditaments in the parish of Hawkshead, in Furness Fells, for ever. This was the origin of the bloom-smithy rent.

According to West,* an iron forge or bloomery existed at Coniston before the time of the civil wars, that is prior to 1650. Probably that which existed by the side of Church Beck, near Dixon ground, was the same.

From information supplied by Mr. Clutton to the late Mr. H. Fletcher,†

* "Antiquities of Furness," by Thos. West, 1774.

† "Archæology of the West Cumberland Iron Trade," by H. Fletcher.—Trans. Cumb. and West. Ant. and Arch. Soc.

it appears that iron ore was worked more or less interruptedly at Bigrigg from 1635 to 1701. In the Stewards and Receivers' Accounts, etc., of money accompted for Egremont iron ore, the first entry is for "Ore gotten at Nicholson Pitts from the 30th March, 1635, to Michas., 1638." There is not any amount attached to this item. In 1643, the sum of 17s. 7d. was received as royalty, and from 1644-48 a few pounds each year. Until 1667 there do not appear to have been any further raisings, but in that and the ten years following the annual receipts were from £50 to £100, and from 1679 to 1701 inclusive, they ranged from £200 to £350, with the exception of 1688, 1693, and 1699. In the two first of these years there were not any receipts and in the last year they amounted to £452 15s. The royalty was 5d. per ton, so that in the year (1699) the output must have been 21,732 tons. One of the partners in this undertaking was Mrs. Ann Hebar, whose name is first mentioned in the accounts in 1682. Another partner was Thomas Addison, Esq., his name first appearing in the accounts in 1693. This mine is evidently the same as that referred to by Robinson* in 1709. He says, "In a place called Langhorn, within that manor (Egremont), is a belly or pipe of iron ore 8 yards deep, in breadth 80 yards, and in length 100 yards, out of which several thousand tons were yearly got, many years last past; the ore was very rich, consisting of button ore and a pinguid shining ore. It answered to His Grace the Duke of Somerset a yearly rent of several hundred pounds. The present lessees are Judicious Thomas Addison, Esq., and Madam Ann Hebar.

"Being at Egremont, I had the curiosity to go to see that rich vein and the stock of ore upon the bank, which was like a little mountain. In that great variety of ore I did not only meet with spar as transparent as the clearest crystal, but stones embossed with bastard diamonds near as sparkling as the real."

A few years ago when some of the old ore workings near Langhorn were re-opened, several old oak spades were met with, the blade and shaft of each of which were made out of one *straight* piece of wood, that is to say, not only were they each formed out of one piece, but there was wanting in them the "lift" of modern spades, being, in that respect, more like the draining tools that are used now. These old spades may have come from the workings which were visited by Robinson, but they more probably belonged to an earlier date, although not so old as the time when the monks of the Abbey of Holm Cultram worked ore in the

* "Essay towards a Natural History of Westmorland and Cumberland," by Thomas Robinson, 1709.

Bigrigg locality; for, along with the old wooden spades, a number of tobacco-pipes were found, and smoking was not introduced into Europe until 1585. In Carew's "Survey of Cornwall," published in 1602, the spades then in use are thus described: "The utter part is of iron, the middle of timber, into which the staff is slopewise fastened." This spade is clearly an improvement upon those found at Bigrigg, for two reasons; first, in having the handle set at an angle instead of being in the same plane as the blade; and secondly, because of its iron edge or shield. At Yeathouse, near Frizington, in some old workings opened out about forty years ago by Messrs. Tulk and Ley, several old oak spades were found, which were, in many respects, identical with those from Bigrigg, but there was one important difference in them, they had each a rim of iron on the front edge, which the Bigrigg spades had not. Originally these latter spades may have been so protected, but as they were in a partially decayed condition when found, the iron edge may have become detached, or it may be that the Yeathouse spade is an improvement upon that found at Bigrigg.

In Robinson's time iron ore was worked in the hills about Langdale and Coniston, for he says, page 61, that "Langdale and Cunningston do abound most with iron veins, which supplies with ore and keeps constantly going a furnace at Langdale,* where great plenty of good and malleable iron is made, not much inferior to that of Dantzick."

About 1690, iron ore was probably being wrought at Millom, as will appear by the following extract from Nicholson and Burns. "Millum lordship hath several parishes within it. That which lies highest and most southwardly is Millum parish; within which stands the Castle of Millum, the capital messuage and ancient seat of the lords thereof, which is placed at the foot of the river Duddon at the east end of a large park, well stored with deer and formerly with great quantities of wood, which Ferdinand Huddleston (having no issue but a daughter) about the year 1690, disposed of in a great measure in building of a large ship, and in making charcoal for his iron forge in that park, where he consumed (as is said) much excellent timber, to the then value of £4,000 and upwards, and was little or nothing profited thereby.† In 1710, the Backbarrow furnace was built by the Machells and Sandys, and in the same year,

* This was probably the old furnace, of which there are still traces, by the side of the River Brathay, between Colwith Force and Little Langdale Farm.

† "History and Antiquities of the Counties of Westmorland and Cumberland," by Nicholson and Burns, 1777.

according to West,* "William and John Machell purchased of Walter Strickland, of Sizergh, Esq., 943 timber trees for £1,700, for the use of" their ironworks in Furness.

In 1745, the Duddon furnace must have been in existence, as it is marked on Speed's map which was published at that date.

In 1747, Joshua Gee, of Shropshire, took a lease of iron ore in the Frizington demesnes, and soon after commenced to work the ore. In September or October, Gee admitted Daniel Stephenson as managing partner. In little over three years from this date Stephenson became bankrupt, and there afterwards arose a dispute between Gee and Stephenson's assignees, as appears from two pamphlets which were issued at the time relating to the dispute. The ore worked was at Yeathouse, and the quantity raised seems to have been between 2,000 and 3,000 tons. Some of it was carted to Parton for shipment, the remainder to Whitehaven, by way of Hensingham. The royalty paid, according to the conflicting accounts in the pamphlets, appears to have been 1s. 6d. per ton.

In 1750 four forges were working in Furness, and they produced the following quantities of bar iron:—

	Tons.
†Cunsey	120
Backbarrow	260
Sparkbridge	120
Coniston	80

In 1750 the Maryport furnace was built, and in 1752 that at Seaton was erected.

In 1753–5 iron ore was worked in the parish of Egremont, probably at Bigrigg, by Peter How, William Hicks, Gabriel Griffith, Dr. Brownrigg, and Joseph Bowes. The royalty paid by them was 1s. 6d. per ton, and during the above-mentioned time they seem to have raised 3,551 tons.

In 1772, according to Pennant,‡ there were extensive mines at Whitriggs, in Furness. They are thus described by him: "The ore is found in immense beds beneath two strata, one of pinel, or coarse gravel, about 15 yards thick; the next is limestone of 20 yards; the stratum of ore is rather uncertain in extent, but is from 10 to 15 yards thick and 40 in extent, and sometimes 200 tons have been taken up in a week. . . . . The ore lies in vast heaps about the mines so as to form perfect

* "Antiquities of Furness," by Thomas West, 1774.

† This forge was by the side of Cunsey Beck, and about three-quarters of a mile from Lake Windermere.

‡ "A Tour in Scotland,' by Thomas Pennant, 1790.

mountains, is of that species called by mineralogists hæmatite and kidney ore, is red, very greasy, and defiling. . . . . The ore is carried on board the ships for 12s. per ton, each ton 21 hundred, and the adventurers pay 1s. 6d. per ton farm for the liberty of raising it. It is entirely smelted with wood charcoal, but is got in such quantities that wood in these parts is sometimes wanting; so that charcoal is sometimes procured from the poor woods of Mull and others of the Hebrides. The port to these mines is Barrow."

In 1774, West speaks of Whitriggs mines as the "Peru of Furness." He says, "The ore is found there at a depth of 20 to 30 yards, it is raised at 3s. 6d. and 4s. per ton, and pays 1s. 6d. per ton to the lord of the soil; it is carted and put on vessels for exportation at 3s., and sells from 11s. to 12s. per ton." He further says, in speaking of Stainton, "The iron mines here have been the richest in Furness."

In 1777, the ironstone of the lower coal-measures at Branthwaite appears to have been worked for use in the ironworks at Seaton and Clifton * At this time, too, iron mines were in existence at Millom.†

In 1782, iron mining had become so important in West Cumberland that, in advertising the sale of an estate of land at Ollby (Aldby), near Cleator Moor, it was mentioned that "there was a great prospect of iron ore."‡

In 1783, an iron ore royalty of 900 acres at Frizington was offered for sale,‖ and in the same year the Maryport furnace was sold, when it was stated that the ore at the works was from Whitriggs, Crossgates, and Inman Gill (all in Furness), and also from Whitehaven.§

In 1794, Whitriggs was still noted for its iron mines. Hutchinson¶ says, "The roads are deeply stained with ore and are crowded with carriages bringing it from the mine." According to the same writer there was, at Crowgarth, near Cleator Moor, "the most singular mine of iron-ore supposed to be in Great Britain. It lies," he says, "in the earth at the depth of 12 fathoms, and the thickness of the band of ore, which is hard solid metal, is between 24 and 25 feet. It was never known to be

* These works were erected about 1750, and abandoned probably about 1781. The site of them may still be traced by the side of the Marron, opposite Furnace House.

† Nicholson and Burns.

‡ "Cumberland Pacquet," Aug. 27th, 1782.

‖ "Cumberland Pacquet," Jan. 21st, 1783.

§ "The Old Maryport Furnace," by John Addison. Trans. Cum. Assoc. for the Advancement of Lit. and Sci., Part IV., 1878-79.

¶ "History of the County of Cumberland and some places adjacent," by William Hutchinson, F.S.A., 1794.

much wrought till the year 1784 and 1785, when it was more generally opened; and so great was the demand for it at Carron foundry, in Scotland, and others, that in 1790 and 1791 the annual exportation was 20,000 tons and upwards." From this work it also appears that iron ore (probably hæmatite) was being wrought in the parish of Arlecdon (most likely at Yeathouse), and that the ironstone from the coal measures at Harrington was being exported at the rate of about 2,000 tons annually, the price being about 11s. per ton.

In 1796, the furnaces at work in these counties and the cast iron produced by them were as follows:—

		Tons.
Bearpot	Cumberland	240
Duddon		325
Newlands	Furness	700
Backbarrow		769
		2034

All this iron would doubtless be produced from local ore, beside which, some of the raw material would probably be exported.

A glimpse of the iron ore trade in 1816 is obtained from the "Magna Britannica."* The authors say, "There is an iron mine also at Bigrigg in the parish of Egremont, not worked for many years, from which considerable quantities were exported to Hull, &c. The ironworks at Seaton and elsewhere in Cumberland are supplied with pig iron from Wales. Some years ago, considerable quantities of a ferruginous sort of limestone were exported from the parish of Arlochden (Arlecdon) to the ironworks at Carron, but the concern has been discontinued. A black stone called catscope, raised at Branthwaite in the parish of Dean, was used in considerable quantities in the ironworks at Seaton, but since the company of that place have discontinued making pig iron (which was about the year 1813), the demand for it has ceased. At Harrington they collect ironstone from the seashore and export a few hundred tons annually to Ulverston. About 300 tons were exported in 1814." It would appear, therefore, that iron ore mining in Cumberland had been almost, if not quite, discontinued in 1816, although it was in all probability still carried on in Furness, for Baines, writing in 1824,† says of that district, "The most valuable mineral productions are roofing slate and red hæmatite, a peculiar ore which is

* "Magna Britannica," by Rev. D. Lysons, A.M., F.R.S., F.A. and L.S., and Samuel Lysons, Esq., F.R.S. and F.A.S., 1816.

† "History, Directory, and Gazetteer, of the County Palatine of Lancashire," by Edward Baines, 1824.

obtained near Ulverston. This is the richest ore in the United Kingdom, yielding the best and most ductile iron, suited for the purpose of the wire-drawers. The ore is also sent to distant parts of England to improve the quality of iron by mixing it in the furnace with the common ores of iron to increase the ductility of the metal. Crossgates Mines are now (1824) suspended, and the reason assigned is that the mine is exhausted. The iron mines at Lindal Moor are, however, in full operation. . . . . It is difficult, if not impossible, to ascertain the total quantity of iron ore raised in Furness, but the average quantity shipped annually by the firm of Harrison, Ainslie, and Co., of Newland, Nibthwaite, Backbarrow, and Sparkbridge, is 10,000 tons. In some years they have raised 15,000 tons, and twice that quantity could be supplied if the demand required it."

In 1825, Anthony Hill, of the Plymouth Ironworks, Wales, leased the iron ore in the Bigrigg and Crowgarth Royalties from the Earl of Egremont and commenced mining operations soon after.

In 1829, according to Parson and White,* there were in the parish of Egremont, "three extensive ironstone mines, belonging to A. Hill, Esq., Mr. Barker, and Fitzsimmons and Co. The iron ore is raised from eight pits, 12 or 13 fathoms deep, and it is found in solid bands, 10 yards broad, and 15 feet thick, but at one of the pits the seam is 30 feet thick. The average quantity of ore raised is about 100 tons per day, and it is all shipped at Whitehaven for the iron foundries of South Wales." From recent inquiries as to the exact position of these mines, it appears that Hill's mines were at Bigrigg, not far from the present post-office. Fitzsimmons and Co. worked at Langhorn, and Barker in the land which is now known as Dalzell's Gutterby. The deposits worked by these mines were all in the first limestone, which, at the points named, rises out to the glacial drift. From Parson and White it also appears that when they wrote, iron ore was being quarried on the Yeathouse estate. They also say that "Frizington Park belongs to Sir F. F. Vane, and has yielded great quantities of iron ore, but the mines have been discontinued."

The state of affairs in Furness in 1836, so far as relates to its iron mines, may be partly learned from the account furnished by Baines.† At that date, he says, "the digging of iron ore in Adgarley has lately been resumed. . . . . Stainton, the village of stones, like Adgarley, is noted for its iron mines. The principal mineral production of this (Urswick) parish is iron, and the ore was formerly obtained in such

* "History, Directory, and Gazetteer, of the Counties of Cumberland and Westmorland," by Wm. Parson and Wm. White, 1829.

† "History of the County Palatine and Duchy of Lancaster," by Ed. Baines, M.P., 1836.

abundance that the mines of Stainton and Adgarley were esteemed the richest in the lordship of Furness. One shaft has been known to yield 140 tons in twenty-four hours, but these beneficial operations were interrupted about twenty years ago by streams of water bursting into the shafts. Recently the works have been resumed in Adgarley, by Messrs. Huddleston and Co., Lessees under the Earl of Derby. . . . . The richest and most productive iron mines in Furness are at Ireleth or Above Town. The mines of Whitridge, or Whitriggs, described by West as the Peru of Furness, are still worked, and yield valuable ore in large quantities though the mine called Crossgates became exhausted, and the works were suspended in 1824. The Lindal Moor mines and the Inman Gill mines continue productive, and the Burton-beck mine has been recently re-opened. It is estimated that about 20,000 tons of iron ore are raised annually in the parish of Dalton, and this is said to exceed the production of any former period in this parish. . . . . Iron ore has been extensively obtained in the Pennington part of the iron mines upon Lindal Moor, but the works were discontinued in 1830-31, though the other portions are still in operation."

In 1834, Messrs. Lindow commenced work at Gutterby, and in 1837-38 Mr. James Attwood was raising ore at Frizington Parks, according to Mr. Tulk, from that part of the estate which lies in Winder Valley. Tulk and Ley were the next to work iron ore in West Cumberland, which they did under lease of the Yeathouse Estate, dated 1st August, 1838. Mr. Tulk, in a letter* (from which several items of information in this paragraph were obtained), says, "Previous to my coming to Cumberland (1837), a person of the name of Satterthwaite had worked the Yeathouse mines for a short time, and, I believe, had obtained 500 or 600 tons. . . . . This mine must have been worked long antecedent to our (Tulk and Ley's) time, for in the course of our working them, we found many remains of what had been shafts and numerous workmen's tools, and some wooden hand-pumps. The shovels we discovered were of oak wood, and merely tipped with an edge of iron." Mr. Ainsworth was the next raiser of iron ore, but previous to his commencing, Mr. Attwood found and worked ore at Birks, and in small quantities at Aldby. The agreement for Attwood's lease of Birks was dated 7th April, 1840.

In 1839, the following companies were working ore in Furness.†

Harrison, Ainslie, & Co., Lindal Moor.
Ulverston Mining Co., Lindal Cote.
Mr. T. Fisher, Butts Beck.
Mr. Fisher, Whitriggs.

* Letter from John A. Tulk to Geo. Dixon, 14th Sept., 1863. † G. M. Tweddel, *op. cit.*

In 1842, the first steam-engine used in the Whitehaven hæmatite district was erected at John Pit, Yeathouse, then belonging to Messrs. Tulk and Ley. Prior to that time the only machines used were the common "jackroll" and the "horse gin." These machines were in fact used for several years after the above date and are still in use in Furness at some of the small pits.

In 1843, the following companies were at work in Furness:*—

Harrison, Ainslie & Co., Lindal Moor.
Ulverston Mining Co., Lindal Cote.
Mr. Huddleston, Stainton.
Furness Co., Whitriggs.
Town and Rawlinson, Butts Beck.

In 1846, the first portion of the Furness Railway from Barrow and Piel Pier to Dalton and Kirkby was opened.

In the same year Messrs. Attwood commenced to work at Woodend. Three years later the following companies were raising ore in West Cumberland :—

	No. of Pits.	Output for the Year. Tons.
Ainsworth & Co., Cleator ...	2 ...	30,000
Hill & Co., Bigrigg	4 ...	20,000
John Lindow, Gutterby	3 ...	20,000
Tulk and Ley, Yeathouse ...	2 ...	15,000
Attwood & Co., Woodend ...	2 ...	15,000
		100,000

The pits working in Furness at the same time are given below.

	No. of Pits.	Output for the Year. Tons.
Harrison, Ainslie and Co., Lindal Moor ...	3 ...	55,000
Town and Rawlinson, Crossgates	3 ...	42,000
Ulverston Mining Co., Lindal Cote	4 ...	29,000
Schneider, Davis & Co., Mouzell	3 ...	25,000
Charles Kennedy, Haulm	1 ...	12,000
Geo. Huddleston, Stainton	2 ...	12,000
Geo. Ashburner, Elliscales	1 ...	7,000
		182,000

Some idea of the extent of the iron ore trade in Furness during the previous 100 years may be gathered from the following Table, which gives the output from the Duke of Buccleuch's royalties alone :†

* "Sketch of Furness and Cartmell," by C. M. Jopling, 1843.

† Trans. Derbyshire Inst. of M. and M. E., Presidential Address, 1876.

AVERAGE ANNUAL OUTPUT IN PERIODS OF 10 YEARS.

	Tons.		Tons.
1750	2,818	1810	9,258
1760	5,277	1820	4,310
1770	6,810	1830	8,080
1780	9,802	1840	13.341
1790	12,491	1850	45,884
1800	11,221		

Operations were commenced by the Eskett Iron Ore Company at Frizington Parks in 1850. In August, 1853, the Parkside Mining Company began to bore at Frizington and soon succeeded in finding ore as will appear from the following list of mines working in 1855.*

About this time, Messrs. R. Barker & Co. were working the Nab-Gill Vein near Boot, in Eskdale. The ore got was carted to Ravenglass for shipment.

IRON ORE MASTERS OF WHITEHAVEN DISTRICT.

Ainsworth & Co., Cleator.
John Stirling, Todholes.
S. and J. Lindow, Bigrigg Moor.
Anthony Hill, Bigrigg and Crowgarth Mines.
Eskett Iron Ore Co., Eskett Pit.
Richard Barker.
Henry Attwood & Son, Woodend and Birks Mines.
Tulk and Ley, Agnes and Yeathouse Mines.
Parkside Mining Co., Parkside and Goosegreen Mines.
S. W. Smith & Co., Highhouse Mines.

WORKERS OF MINES IN THE FURNESS DISTRICT.

Harrison, Ainslie & Co., Lindal Moor, Whitriggs and Gillbrow.
Schneider, Hannay & Co., Park Mousell, Whitriggs, Old Hills, Newton.
C. S. Kennedy, Roanhead.
J. Rawlinson, Crossgates, Carr-Kettle, Rickett Hills.
H. Kennedy & Co., or Ulverston Mining Co., Lindal Cote, Eure Pits.
Brogden & Co., Stainton, Adgarley, Bolton Heads.
Messrs. Fell, Stainton.
George Ashburner, Elliscales.

About 1855, a dispute arose between the Messrs. Attwood and the Lessors of their Woodend Mines which has now an historic interest, and which therefore will be briefly outlined.

At the time when Messrs. Attwood took their Woodend Lease (1846) it appears to have been a common practice to fix the royalty ton at so many "kibbles" (in their case ten), the standard kibble having the form of

* "Iron Ores of Great Britain," Part 1, 1856.

the frustum of a cone of which the depth was 18 inches, and its upper and lower diameters 20 inches and 11 inches respectively. The average weight of ten such kibbles of ore, strike measure, was about 35 cwts., and that was considered to be practically a royalty ton, although it was only a ton by measure and not by weight. The practice of measuring ore in this way doubtless arose when the "kibble" was exclusively used in raising iron ore from the mines, as in all probability it would be in the earlier days of mining, when the excavations were of small extent and near the shaft. Even at the present day, in very small mines in Furness, the "kibble" and also the "horse gin" are still in use, and fifteen years ago they were very common indeed in that district. As mines became more extensive it would be found advantageous to use the "bogy," and in 1855 this mode of conveyance was largely adopted in the Whitehaven district; the capacity of a bogy then being usually looked upon as equal to that of two kibbles, that is to say, five bogies were reckoned a ton. About this time it was alleged that Messrs. Attwood had increased the size of their bogies but still continued to look upon five of them as holding a ton, a proceeding which gave rise to the dispute above referred to. In connection with this matter it may be mentioned that at the present time it is a very common practice to let the getting of iron ore to the miners of the Whitehaven district by the ton of five bogies, a practice which is evidently a survival of the one just described, the only difference being that what was formerly called a "royalty ton" is now known as a "miner's ton," royalties being at the present time and for some years past paid on the *weight* and not on the *measure* of ore raised.

In 1857, the first part of the Whitehaven, Cleator, and Egremont railway from Whitehaven to Egremont and Frizington was opened, and from that time the iron ore trade of West Cumberland has gradually and rapidly increased. A similar effect upon the mining industry of Furness followed the opening of the Furness railway, as will be apparent from an examination of the Table on next page, which, besides giving the annual production of hæmatite and the dates on which the principal local railways were opened, also shows the time at which the principal existing ironworks in both districts were erected.

Previous to the opening of the Whitehaven, Cleator, and Egremont Railway, the ore raised in the Whitehaven district was conveyed from the mines in carts, a large part of it being taken to Whitehaven for shipment. Some was carried to the depôt near Woodend Gardens, and despatched by the Furness Railway, which was opened from Whitehaven to Ravenglass in 1849, and to Foxfield in 1850. When not led directly into

PRODUCTION OF IRON ORE.

Year.	CUMBERLAND.			FURNESS.		
	Ironworks erected.	Railways opened.	Total Output of Hæmatite.	Ironworks erected.	Railways opened.	Total Output of Hæmatite.
1841	Whitehaven	.....	.....	.....	.....	.....
1846	.....	.....	.....	.....	Furness, Barrow to Dalton and Ireleth	.....
1849	.....	.....	100,000	.....	.....	182,000
1851	.....	.....	.....	.....	F. R., Dalton to Lindal	.....
1852	.....	.....	.....	.....	F. R., Lindal to Halfway Bridge	.....
1854	.....	.....	.....	.....	F. R., Halfway Bridge to Ulverston	354,685
1855	.....	.....	200,788	.....	.....	336,829
1856	.....	.....	259,167	.....	.....	464,853
1857	Harrington	Whitehaven, Cleator, and Egremont Railway to Egremont and Frizington.	323,812	.....	F. R., Ulverston and Lancaster	592,390
1858	Workington	.....	331,544	.....	.....	438,456
1859	.....	.....	400,306	Hindpool	.....	445,046
1860	.....	.....	466,851	.....	.....	520,829
1861	.....	.....	472,095	.....	.....	519,180
1862	.....	.....	533,120	.....	.....	559,391
1863	West Cumberland	W. C. and E. Railway, Rowrah extension.	690,083	.....	.....	658,642
1864	.....	.....	784,174	.....	.....	691,421
1865	.....	W. C. and E. Railway, Marron extension.	678,831	.....	.....	607,439
1866	.....	.....	706,505	Carnforth	.....	685,726
1867	.....	.....	709,037	.....	.....	667,356
1868	.....	.....	725,248	.....	.....	767,625
1869	.....	.....	848,974	.....	.....	784,507
1870	Maryport Millom Solway	.....	1,014,143	.....	.....	784,507
1871	.....	.....	976,874	Askham	.....	931,048
1872	Mossbay Lonsdale	.....	954,505	.....	.....	909,077
1873	Parton	.....	1,021,690	.....	.....	975,826
1874	Derwent	.....	901,667	.....	.....	914,357
1875	.....	.....	935,360	North Lonsdale	.....	834,484
1876	Lowther	.....	1,082,812	.....	.....	908,664
1877	.....	.....	1,081,256	.....	.....	993,012
1878	.....	.....	1,082,924	.....	.....	984,781
1879	Distington	.....	933,369	.....	.....	976,822
1880	.....	.....	1,148,246	.....	.....	1,266,503
1881	.....	.....	1,615,635	.....	.....	1,189,836
1882	.....	.....	1,725,478	.....	.....	1,408,693

ships the ore carted to Whitehaven was placed in depôts in different parts of the town. One of these depôts was on the site of the Bransty Hotel, another where the cab stables are, a third was in Duke Street, and a fourth behind the Butter Market. Ore was also sent in carts by Messrs.

Tulk and Ley from Yeathouse *via* Kidburngill and Winscales to their ironworks at Seaton, near Workington.

In 1880, the numbers of persons employed in the hæmatite mines of Cumberland and Lancashire were 6,500 and 4,233 respectively. In 1854 only 369 were engaged in the Cumberland pits. The first return for Lancashire is in 1873, when there were 3,222. In the same year there were 4,442 persons employed in the Cumberland mines.

In 1882 the various companies raising ore, and the quantity obtained by each company during that year in the two districts, are given in the mineral statistics of the United Kingdom as under, and excepting those marked thus * they are all working now (September, 1884):—

Name of Mine and Owner.	Ore raised in 1882. Tons.
Bigrigg, Lord Leconfield ...	45,929
Cleator Moor, do.	43,440
*Birker Moor, South Cumberland Iron Co.	1,157
Birks, Wood Brothers	17,348
Dalzell, Maryport Iron Co. ...	20,739
Jacktrees, Carron Co.	76,124
Eskdale, Whitehaven Iron Co...	3,164
*Scalelands, Scalelands Mining Co.	1,282
Whicham, Whicham Mining Co.	41,765
Cleator, Cleator Iron Ore Co....	61,251
Crossfield, Crossfield Iron Ore Co.	90,941
Crossgill, Maryport Iron Co. ...	10,102
Ehen, Ehen Mining Co. ...	10,398
Egremont, Egremont Mining Co.	4,085
Eskett, Eskett Iron Ore Co. ...	43,200
„ J. Postlethwaite ...	63,427
Knockmurton and Kelton, Baird and Co.	61,153
Gillfoot Park, Gillfoot Park Mining Co.	72,510
Eskett Park, Salter and Eskett Park Mining Co.	14,815
Parkside, Parkside Mining Co.	33,100
New Parkside, New Parkside Mining Co.	10,378
Frizington Parks, Bain and Co.	9,556
Goose Green, „ ...	13,380
High House, Fletcher and Hodgetts	73,779
Carried forward ...	823,023

Name of Mine and Owner.	Ore raised in 1882. Tons.
Brought forward ...	823,023
Holebeck and Ratten Row, Dalmellington Iron Co. ...	8,281
Montreal, John Stirling ...	187,738
Moor Row, Maryport Iron Co.	11,782
*Mowbray, Mowbray Iron Ore Co.	11,633
*Pillar, Ennerdale	10
*Iron Crag, „	400
Salter Hall, Thomas Dixon and Co.	31,348
Woodend, Bain and Co. ...	47,795
Bigrigg Nos. 1 and 2, S. and J. Lindow	2,174
Sir John Walsh Pit, S. and J. Lindow	4,574
Longlands, S. and J. Lindow ...	19,908
Lonsdale, „ ...	14,186
Hodbarrow, Hodbarrow Mining Co.	453,523
Wyndham, Wyndham Mining Co.	69,185
Winder, Winder Iron Ore Co....	1,869
Woodend, Moss Bay Co. ...	8,907
*Gutterby, Maryport Iron Co. ...	2,563
Todholes, H. Dixon	2,060
Winder Agnes No. 7, Winder Iron Ore Co.	24,519
	1,725,478

FURNESS.

Name of Mine and Owner.	Ore raised in 1882. Tons.
Bircume, Lindal-in-Furness ...	6,517
Dalton, M. Kennedy	7,080
Dalton, Askham and Mouzell Iron Co., Limited	45,743
Elliscales, J. Ashburner ...	8,300
Highfield, Cumberland Iron Mining and Smelting Co. ...	3,812
Lindal Cote, Eure Pits, etc., Ulverston Mining Co. ...	18,627
Lindal Moor, Askham and Mouzell Iron Co., Limited ...	6,336
Lindal Moor (Whitriggs and Gillbrow), Harrison, Ainslie, and Co.	296,824
Mouzell, Askham and Mouzell Iron Co., Limited	98,772
Old Hills, Barrow H.S. Co. ...	3,028
Carried forward ...	495,039

Name of Mine and Owner.	Ore raised in 1882. Tons.
Brought forward ...	495,039
Park, Barrow H.S. Co.... ...	323,225
Pennington, Parkside Mining Co.	39,604
Roanhead and Askham, Kennedy Brothers	277,997
Stank, Barrow H.S. Co. ...	135,761
Whitriggs, „ ...	60,215
Yarlside, Yarlside Mining Co....	59,294
Newton, Barrow H.S. Co. ...	581
Stainton „ ...	100
High Cross Gates, Askham and Mouzell Iron Co.	12,838
Stainton Urswick, J. Brogden and Sons	3,999
	1,408,653

During the last thirty years many changes have taken place in the art of mining as practised in these districts, but by far the greater number of them are due to the simple circumstance that the depth at which the ore was wrought has been gradually increasing. This from time to time necessitated the employment of better machinery, so that from the "jackroll" and the "gin" there has been a gradual evolution through the small engines, with a single cylinder geared back three or four to one, and used for both pumping and winding, up to the large double-winding engines and the direct acting compound pumping-engines now in use. Hemp ropes have given place to those made of steel, except in some of the shallow pits in Furness where round hemp ropes are still in use. In breaking the ore, dynamite and blasting gelatine have in a great measure superseded gunpowder, which was used exclusively until about thirteen years ago. In exploring operations, the Diamond Rock Borer has come to the assistance of the percussive machine, and deep boreholes are now much commoner than formerly.

COAL.

That the Romans were acquainted with the use of coal, and that it was actually used in Britain, is certain, for Bruce, in his "Roman Wall," says that "in nearly all the Stations on the line the ashes of

mineral fuel have been found," and, "in some, a store of unconsumed coal has been met with." The "Magna Britannica," speaking of some excavations made in the Roman station at Maryport by the Senhouse family in 1776, says, "That coals had evidently been used in the fire-places." That these coals should have come from a point outside the Cumberland coal-field is very improbable, so that it may be stated with some degree of confidence that coal was wrought in Cumberland over 1400 years ago. That it was obtained in any but small quantities is very improbable, even throughout the succeeding thousand years, for in those remote times there would be abundance of wood, even in the absence of peat, to satisfy the simple requirements of the people who then inhabited this part of the country.

Coming down to times when the use of coal became more extensive and general, it is doubtful in what part of Cumberland it was first worked for sale. The late Mr. Isaac Fletcher thought it was at Whitehaven, about the year 1620, but from a passage in Robinson's "Natural History of Cumberland and Westmorland" it is probable that coal was worked at Bolton some time before it was worked at Whitehaven. Speaking of the copper works at Keswick, Robinson says that the coal used at these works was from Bolton Colliery. Now the copper works were built in 1567 and destroyed by Cromwell in 1650, and although they were rebuilt about 1690 and continued in operation until about 1717, yet it is clearly to the first part of their existence that Robinson refers, so that coal must have been wrought at Bolton before 1650, and possibly from the time the copper works at Keswick were first built, *i.e.* in 1567. According to the State Papers, it appears that as early as 1568 coal was used at these works, for a complaint was then made by the owners that they had a great difficulty in getting coal; where it came from is not stated, some of it probably was from Workington.

The Sandford Manuscripts, in the library of the Dean and Chapter at Carlisle, describing Workington in 1676, say there is "A fair haven, but not so much now frequented with ships, the coleyery being decayed thereabout;" and Denton, writing in 1680, says there is "a salt pan and colliery worth £20 a-year within the demesne." It is quite clear from these quotations that coal must have been wrought at Workington some years prior to 1676.

In 1681, William Orfeur, Esq., of High Close Plumbland, made his will, by which he bequeathed to his eldest son William Orfeur, "all my husbandry geare whatsoever and all loose wood about my house and all manner of geare belonging to my Colliery at Outersyde."

A document preserved in Lincoln's Inn, and headed, "Case of Sir John Lowther, Bart., and the inhabitants of the town and port of Whitehaven, with reasons against a bill for laying duty on coals to make a harbour at Parton, a small creek within a mile of the said town," states that in the year 1566, as appears by a survey of the shipping and trade of the county of Cumberland (taken by a commission under the Great Seal), there were but six houses, and no shipping except one small picard of eight or nine ton at Whitehaven. Sir John Lowther's family were the first that introduced any considerable trade by sea into that county, and by building a pier and some ships at Whitehaven they made some advances towards it. Nevertheless, the town was still very small until Sir John Lowther applied himself with great charge and industry to raise it. The country adjacent afforded coals sufficient for a staple export, but a great part of them were in the hands of small freeholders, and could not be wrought without great and expensive levels, which must go through several people's lands, and draining all upon the rise would enable such as have more of the charge to undersell and ruin these (?), so that the working of them under these circumstances was impracticable, and they were lost as well to the owners as to the country until Sir John Lowther, at his own cost, introduced the art of carrying on levels, and of working what was under level by engines, a thing unknown in that country before."

The document from which this extract is taken is without date, but as the Bill (which was opposed) for enlarging the pier and harbour of Parton was passed in 1705, the document doubtless belongs to that year. Sir John Lowther, above alluded to, succeeded his father, Sir Christopher, in 1644. It seems, therefore, quite legitimate to assume that coal was worked at Whitehaven prior to this date, and that the harbour and shipping provided by Sir John's family were for the purpose of exporting the coal. The date fixed by Mr. Fletcher is, however, perhaps a little early, for Hutchinson, speaking of Whitehaven, says "that in 1633 the town consisted of nine or ten thatched cottages; in 1693 there were 450 families here, consisting of 2,272 inhabitants; in twenty-two years more they were increased to 800 families." Not much mining would be done at the time there were only nine or ten thatched cottages in existence.

The earlier operations at Whitehaven would be carried on near the surface, and probably by means of "day levels" along the outcrop edges of the Bannock Band and Yard Band, which rise to the surface in the hillside, whereon now stand Mount Pleasant and the New Houses. The

coal thus obtainable would, no doubt, at the low rate of working then necessary, serve for a considerable time, but before 1709 the necessity had arisen for sinking pits, and at that date there were seven at work, with an aggregate output of 800 tons per week. The names of these pits, the seams worked, and the output of each for the week ending November 9th, 1709, are as follows:—

Name of Pit.	Tons.	Loads.	Seam Worked.
Gameriggs	169	0	Main Band.
Murrah...	228	0	
Grayson	72	7	Yard Band.
Fox	141	0	Bannock Band.
Boll	124	0	
Mowson	3	1	
Darby	57	2	
	795	2*	

The amount of the pay-bill (which appeared to include every item except agents' salaries) for the above week was £72 14s. 7d., including £32 13s. 5d. for cartage, so that the cost at the pit per imperial ton of 22 cwts. was about 1s. Eleven of these weekly pay-bills for the same year, gave an average raise of 743 tons per week, or 38,636 tons a year. The selling price at the pit's mouth was then about 2s. per ton.

The rate at which the workmen were then paid was as under †:—

	s.	d.	
Haggers		10	per Day.
Trailers...		8	„
Brakesmen		8	„
Winders		8	„
Corvers	1	0	„

Mr. Fletcher says :—"In an account of some levelling made in 1713, in the neighbourhood of Keekle, Low Wreah, and Priest Gill, mention is made of 'Mr. Fletcher's pit on the Moor.' The same document shows that coal was then working near the Keekle. "Christian" pit and "Water" pit are mentioned, and allusion is made to Captain Senhouse's Yard Band, last wrought toward Sands Close.

About 1718, Carlisle Spedding was appointed Engineer of the Whitehaven Collieries. He was the inventor of the "Steel Mill," and of "Coursing the Air" in Collieries, and, very curiously, he was killed by an

* 8 loads were a ton and a ton was about 22 cwts.

† From Paper by Mr. Isaac Fletcher "On the Archæology of the West Cumberland Coal Trade." Transactions of the Cumberland and Westmorland Antiquarian and Archæological Society, 1878. To this paper the author is indebted for several pieces of information herein relating to the coal-field.

explosion of fire-damp in 1755. The pits which were sunk under the direction of this able Engineer were named, in the Howgill division, Saltom (1731), Thwaite and Ravenhill, Country, Moss, Arrowthwaite, Parker, Fish, and Hinde (1737), Duke (1747), Kells (1750), Fox (1752), King (1753). In the Whingill division—Taylor, Hunter, Carr, Fox, Daniel, Green, Watson, Pedler (prior to 1731), Harras, Pearson, and Jackson.*

The first "fire engine" employed on the Whitehaven Colliery was at "Gin" pit, the site of which is now occupied by that part of Whitehaven called the "Gins." It was erected for the purpose of pumping water. Previous to that time the mines below the "day levels" had been drained by horse-moved machinery. Hutchinson, referring to this pit, says, "They drew the coals and water also from the pit with horses and vertical 'gins.' . . . Drawing the water by these machines, or 'gins,' with horses, was very expensive, and took away much of the profit arising from the colliery. To remedy this, the late Sir James Lowther (who was in possession of the estates from 1706 to 1755) is said to have purchased the materials of a fire or steam engine in London, which had been used there for raising water for the use of the city. Report says that this was the second steam engine in England. It was sent by a ship from London to Whitehaven, and fixed upon a pit near the 'Gins,' which pit is said to be nearly 60 yards deep. As the number of the pits increased, the water increased, which caused another more powerful engine to be erected. By these two engines a considerable extent of coal was drained, from which the town and export market were several years supplied. A pit was then sunk about half-a-mile from the staith, which is close by the harbour. The pit is called 'Parker' Pit, and from it the first wagon-way was laid in this county."

In 1729, the sinking of Saltom Pit was commenced. A fire engine was erected at that pit having a 40-inch cylinder. The boiler was 11 feet diameter, and the cylinder was fixed to it. A few years after a second engine was erected similar to the first, and the two worked together until about 1782, when they were pulled down and a larger one was erected in their place. This engine, on the atmospheric principle, had a 70-inch cylinder and 6-feet stroke. It continued to work at Saltom until 1867. The pit ceased to draw coals in 1848.

In 1731, the following pits were at work in the Whingill portion of the Whitehaven Colliery:—Pedlar, Carr, Pearson, and Taylor pits. Their aggregate weekly output was from 300 to 400 tons.

* Mr. Isaac Fletcher, *op. cit.*

each from one to another, and were worked by one sliding rod from the engine.* This is probably the engine that Pennant saw and of which he speaks above

Speaking of Workington, Pennant says (1772), "it contains about 4,000 or 5,000 inhabitants. They subsist by the coal trade which is here considerable." Of Maryport he writes, "the second house was built in only 1750. Now there are above a hundred, peopled by 1,300 souls, all collected together by the opening of a coal trade on the estate."

Nicholson and Burns, writing in 1777, of Whitehaven, say, "The coal mines in this place are perhaps the most extraordinary of any in the known world. . . . . The mines are sunk to the depth of 130 fathoms, and are extended under the sea to places where there is, above them, sufficient depth of water for ships of large burden. There are the deepest coal mines that have hitherto been wrought. . . . There are four fire engines belonging to the colliery, which, when all at work, discharge from it about 1,228 gallons every minute." These authors also refer to other coal workings in different parts of Cumberland, as follows:—*Moresby.*—"The demesne is large and woody, and rich in coal mines, for the exportation of which, the harbour at Parton is very convenient." *Harrington.*—"There is also a good colliery, and the present owner, Henry Curwen, Esq., having made a new quay or wharf at the foot of the river, exports large quantities of coal to Dublin and other places." *Workington.*—"Here are salt pans and a good colliery." *Dean Moor.*—"On which common are also some coal pits." *Weary Hall.*—"Where there is now a good colliery." *Outerby.*—"This is a little manor of Sir Gilfrid Lawson's, whose ancestor, Sir Wilfrid Lawson of Isell, purchased it from Charles Orfeur of High Close, in whose family it had been for many generations. There is a good colliery at this place."

"In the twenty-six years ending with 1781, 765,530 tons (of thirty-six Winchester bushels each) were raised from the Broughton pits and shipped at Maryport. The selling price to ships was 3s. 4d. per ton. Cost of hewing, 9d., and trailing 5½d. per ton."†

In the *Cumberland Pacquet* for Sept. 24th, 1782, there were advertised to be sold several steam engines, or, as they were then called, fire-engines, at the Weary Hall Colliery, in the parish of Bolton. They were thus described:—"A current-going fire-engine, the cylinder 42 inches in diameter; boiler, 15 feet diameter, with a cast iron top, the bottom malleable; two cast iron working barrels, 9 feet long, and 11½ inches diameter;

* "History and Description of Fossil Fuel," 1835.

† Mr. Isaac Fletcher, *op. cit.*

and 26 fathoms of staved pumps, 11½ inches diameter. Also a smaller fire-engine, the cylinder 30 inches diameter; one cast iron working barrel, 9 inches diameter; 12 fathoms of staved pumps, 9 inches diameter; with a cast iron boiler top."

Hutchinson,* writing in 1794, says, "There are near Whitehaven, three holes, called Bear-Mouths, through which the men and horses go down to the coal works, they are called Howgill Bear-Mouth, Ginn's Bear-Mouth, and Greenbank Bear-Mouth." These openings are in existence now. Speaking of the harbour, this writer says, "The new quay was lengthened in 1767. The North Wall was begun in 1770 and finished in 1784. The Old Quay was lengthened in 1792." Hutchinson also notices other collieries in Cumberland in the words following: *Moresby.*—"There are several coal mines within the Manor, which supply the little haven of Parton with the chief export." *Harrington.* —"Coals are shipped here and wrought in the adjacent mines." *Workington.*—"The coal trade is of the greatest importance. There are two workings almost contiguous to Workington; nine pits belong to Mr. Curwen, and five to Mr. Walker, as agent to the trustees of Anthony Bacon, Esq., M.P., London. They generally ship, on account of both parties, about 150 wagon-loads per day, (Sunday excepted), of which Mr. Curwen ships near 100 loads, each wagon contains three English tons of coals, for which the owner of the vessel is charged 10s. 6d. . . . The pits are from 40 to 90 fathoms in depth, having generally two or three workable bands; the first 3 feet, the second 4 feet, and the third 10 feet to 11 feet; the roof of the two former vary; that of the main coal is of the finest white freestone, generally 20 yards in thickness. Mr. Curwen is at this time employed in endeavouring to open the Chapel Bank Colliery, the shaft now sinking is upwards of 12 feet diameter. . . . In the coal works are between 500 and 600 persons employed. The fire-engines have greatly lessened the number of horses used." *Maryport.*—"Is at present a considerable market town and port for the exportation of coals. A few years ago, it was like to have lost its population by the failure of the coal mines, but new seams of coal having been opened, trade now flourishes again." *Aspatria.*—"Coals at Outerside." *Gilcrux.*—"Plenty of fine coal." *Bolton Row.*—"Where is a good colliery. . . . Coals bought at the pit, five Carlisle pecks for 6d." *Westward.*—"Here are some coal mines, but little wrought." "On *Warnell Fell* is a considerable colliery, carried on with much spirit and success under the Duke of Northfolk, who holds it by a long lease from the Duke of Portland. By the report of the very intelligent manager of this colliery,

* *Op. cit.*

Mr. Joseph Dobson, there is sufficient evidence in the works themselves to prove that coals have been dug here 300 years ago, which was almost as soon as coals were generally made use of in the kingdom for fuel. Coal of an extraordinary good quality is said also to abound everywhere on the estate of Warnell Denton, but owing to some untoward circumstances, these mines have not been worked these forty years." The exports of coal between 1781 and 1792 is given by Hutchinson as follows:—

CUSTOM HOUSE RETURNS.

	Whitehaven. Tons.	Workington, Maryport, and Harrington. Tons.	Total.
1781 ...	119,540 ...	118,525 ...	238,065
1782 ...	123,393 ...	118,164 ...	241,557
1783 ...	131,442 ...	125,526 ...	256,968
1784 ...	128,312 ...	136,336 ...	264,648
1785 ...	156,279 ...	151,738 ...	308,017
1786 ...	188,082 ...	142,622 ...	330,704
1787 ...	109,181 ...	164,828 ...	274,009
1788 ...	193,633 ...	162,228 ...	355,861
1789 ...	162,611 ...	160,046 ...	322,657
1790 ...	144,947 ...	152,819 ...	297,766
1791 ...	117,401 ...	179,645 ...	297,046
1792 ...	125,840 ...	169,291 ...	295,131

In 1799, the Town End Pit, Greysouthen, was sunk.

On the 23rd March, 1805, William Pit, near the Whitehaven harbour, reached the Main Band at a depth of 92 fathoms. It took forty-six weeks to sink, including eight weeks occupied in walling the sides.* The winding engine erected at this pit was a beam engine on the atmospheric (Hyslop) principle. Some of its chief dimensions were as follows:—

Steam Cylinder, 44 inches diameter.
Stroke, 3 feet 8 inches.
Cold Cylinder, 28½ inches diameter.
Stroke, 4 feet 9 inches.
} These Cylinders were placed at opposite ends of the beam.

Condenser, 6 feet long, and 16 inches diameter.
Cold Water Pump, 7 inches diameter, and 2½ feet stroke.
Air Pump, 18 inches diameter, and 2 feet 9 inches stroke.
Beam (wood), 20 feet long.
Fly Wheel, 20 feet diameter.
Rope Barrel, 9 feet diameter × 6 feet broad.
Boiler, 13 feet diameter, and 10 feet high.

This engine was pulled down and broken up in 1850.

A temporary pumping engine was also erected in 1810 at this pit, on the atmospheric principle. The cylinder was 44 inches diameter, and the boiler (haystack) 15 feet diameter. The beam was of wood with

* "Philosophical Magazine," 1805, Vol. II., pages 255-277.

segmental ends. The permanent pumping engine (atmospheric) afterwards erected in 1810 at this pit, is still at work there. The cylinder is 80 inches diameter.

In 1805, William Walker, Esq., worked the Gunnersdale Colliery, near Gilgarron. The seam wrought was the Two-feet. In 1811 the Countess and Castlerigg Pits in the Whitehaven Colliery were sunk..

In 1806 a search was commenced for coal near Holehouse, and shortly afterwards two pits were sunk to win the New Scalegill Colliery. One of the pits, the first sunk, was called Henry Pit. It was 9 fathoms to the Main Band and 17 fathoms to the Yard Band. The other pit was called Elizabeth Pit, and was 16⅞ fathoms to the Main Band and 26⅔ fathoms to the Yard Band.*

In 1816 the following references to Cumberland Collieries are made in Lyson's "Magna Britannica." "The Whitehaven Collieries, now the property of the Earl of Londsdale, have been worked ever since (since they were first worked for export) with increased spirit and activity, and are at this time by far the most extensive concern of this nature in the kingdom. . . . There are now two steam engines for pumping water and three for raising coals at each of the principal collieries of Howgill and Whingill, and there is a steam engine for raising coals at the Scalegill Colliery. The larger pumping-engine on the Whingill Colliery is of 110 horse-power, that at Saltom Pit on the Howgill Colliery is of about 80 horse-power. The produce of the two collieries is about 50,000 wagon loads (2¼ tons), that is about 112,500 tons from each. . . . Wagons were first introduced about or soon after the year 1720 by Mr. Carlisle Spedding, Sir James Lowther's agent, who had seen them at the Newcastle works. In 1813, the wagon-ways which were before of wood were laid with cast-iron.†

"The next colliery in point of extent is that of Workington, belonging to J. Christian Curwen, Esq., which exported for the five years ending with 1813, 28,000 wagon-loads annually. Mr. Curwen's collieries at Harrington exported during the same period about 19,000 wagon-loads annually, and those of Broughton Moor from Maryport about 8,000 wagon-loads. At Maryport, about 4,000 wagon-loads during the same period were annually exported from Mr. Senhouse's colliery, and about the same quantity from that of Mr. Walker's colliery at Flimby Wood, held under the Earl of Lonsdale.

* "Colliery Guardian," 18th May, 1883.

† These were fish-bellied rails, used both underground and on the surface. There were some in use at this colliery until about eight years ago.

"Mr. Curwen has four pits in work at Workington from 60 to 90 fathoms. There are about 400 persons employed in the colliery at Workington. In this colliery there are sixteen engines, three at Harrington, and two at Broughton Moor. The engine at Isabella Pit* at Workington is of 66 inches diameter. This is a double-powered engine, the steam pressing on the piston both at the top and bottom, which makes it of equal power with a single engine whose cylinder is 93¾ inches diameter.

"The collieries at Dearham and Arlochden are worked but to a small extent.

"The Camerton Colliery is worked solely for the Seaton Iron Foundry. The Distington Collieries are worked only for the limeworks and for inland sale. The collieries on Lord Lonsdale's estate, near Workington, have not been worked for about 30 years.

"The principal inland collieries are those at Bolton Pasture, held under the Earl of Egremont by Fawcett, Crosthwaite, and Company; supposed to have a sale of about 15,000 wagon-loads annually. Greysouthen, belonging to Messrs. Walker, Harris and Company; supposed to have a sale of about 1,000 wagon-loads annually. There are collieries also at Little Broughton, Outerside, Gilcrux, Allhallows, and Huer-hill."

In 1829 Parson and White gave a brief outline of the Cumberland coal-trade, the substance of which is as follows:—*Distington.*—"Here are both coal-mines and extensive limestone quarries." *Harrington.*—"Coal is raised in this parish in large quantities from mines belonging to the Curwen family." *Moresby.*—"A large coal-field lies under the surface, and the Earl of Lonsdale, the lord of the manor and owner of a great part of the soil, is now cutting a level and making other preparations for drawing and winning it. A tunnel was some years ago cut through Redness Point to continue a railway to Parton, but it will soon be used for the purpose of conveying coal from the new mines in Moresby parish to Whitehaven." *Parton.*—"Coals were shipped here till about forty years ago, but few of the present inhabitants have any recollections of the traffic." *Whitehaven.*—"In 1826, upwards of 135,632 chaldrons were exported hence, and in the following year, 114,692 chaldrons 24 bushels was the quantity entered at the Custom House." *Workington.*—"The coal-trade is the grand staple of Workington, and the numerous collieries in this and the neighbouring townships give employment to a considerable portion of the population. The shaft of the Isabella Pit is

* Sunk between 1812 and 1818.

no less than 300 yards deep and is drained by a steam engine of 160 horse-power, erected in 1811 ; but most of the other mines are not more than 100 to 200 yards deep. . . . About 200,000 tons of coal are shipped here annually from the mines belonging to H. C. Curwen, Esq., and John Fletcher & Thomas Westray." *Dearham.*—"Abundance of coal is raised here and exported at Maryport."* *Gilcrux.*—"Large quantities of coal and lime are got here." *Plumbland.*—"Both coal and limestone are raised here in abundance."

In 1831, the Crummock Colliery, near Mealsgate, was working, and Mr. Williamson Piele,† who then wrote a short notice of a peculiar change which he had witnessed in the nature of two of the coal seams, there alludes to "the old Main Band Colliery to the rise."

In 1832, the Whinbank Colliery, near Gilgarron, was working the Main Band. At this time the Gilgarron Colliery was working the "Yard" Band.

In 1837, the sea broke into the Workington Colliery and drowned all the workings along the west side of the colliery. This catastrophe was brought about by the workings, in spite of repeated warnings, being carried too near the sea-bed, having at the time of the accident approached opposite Salter Beck to within about 14 fathoms of it. The workings then flooded have remained so ever since. Mr. Dunn, who formerly had the management of the Chapel Bank Colliery, gives the following account of the catastrophe :—"Another of those frightful events," he tells us, "took place at this (Chapel Bank) Colliery on the 30th July, 1837. The two pits, Lady and Isabella, were worked at the distance of 1,500 yards under the Irish Sea, with a 10-feet seam, which was 90 fathoms deep ; both pits being situated close upon the sea shore. In the course of a long rolly-way, and in the intersections of several dykes, a good deal of level had been lost before arriving at the inmost workings, which were also driven considerably to the rise at the rate of one in three, which at length brought them within 15 fathoms of the bottom of the sea. The ordinary manner in which the colliery was worked was—width of working, 5 yards ; and the pillars, 7 or 8 yards, which was barely sufficient to bear the roof unbroken. The manager of the colliery having no fear of the consequences, and being anxious to produce

* At this time, and for some years before, "cinder ovens" were in existence at Dearham.

† "Notes on a Singular Transformation of the Seams of Coal into Stone at Crummock Colliery," by Williamson Piele. Trans. Nat. His. Soc. of Northumberland and Durham, Vol. II., pp. 178 80.

an excessive quantity of coal to supply the market, proceeded in a most reckless and unguarded manner to attenuate the pillars, already scarcely sufficient to afford support to the superincumbent strata. His proceedings were deprecated by everyone conversant with the colliery; and it had not been allowed to proceed for any length of time till warning was given of approaching danger by some heavy falls of the roof accompanied by currents of salt water.

"The danger of letting in the sea now became the subject of common conversation, but week after week passed on without any change in the system. In the meantime several of the men left the colliery through dread of consequences; and one of the under-agents expressed his convictions and fears to me in a succession of letters.

"In consequence of these letters, the proprietor was apprised as to the risk he was incurring, and which induced him to question the manager; but he silenced all his fears with asseverations of safety. Matters were, therefore, allowed to go on under implicit reliance on the present management, notwithstanding the repeated heavy falls and discharges of water, which were rendered still more hazardous by the contiguity of some material faults. The last communication I received on this matter ran as follows:—'Unless some interference can be made, a very few days or weeks will most assuredly bring down the waters of the sea; and that opinion is now so generally expressed that men are leaving the colliery every day.' Thus matters stood till the 30th of July, 1837, when the whole neighbourhood was appalled by the breaking-in of the sea; and so extensive was the commotion that many persons, at the distance of hundreds of yards, observed the swirl of the waters directly over where the fracture took place.

"A few of the pitmen escaped by groping their way to the day-hole in the rise workings underneath some cottages at Chapel Bank."

In 1838, the following pits were working at Dearham, their daily output at that time being as shown:—

	Tons.	
Low Crosshow Pit	30	Cannel and Metal Bands.
High „ „	20	
Croft Pit	20	

Hagging and Trailing at the two Crosshow pits was then 2s. 9d.; at Croft Pit, 3s. 3d. per ton. Selling price of coal at pit top, 5s. 10d. per ton.

About 1840, the Maryport and Carlisle Railway was partially opened, and in 1846 and 1847 the Whitehaven Junction and the Cockermouth and Workington Railways, respectively, were opened. The construction

of these lines led to a great increase in the production of the coal-field as might be expected, and as will appear later on, when the output during recent years is considered.

In 1854, the Eliza Pit near Bulgill was sunk by John Steel & Co., on the site of an old pit called the "Water-Bob" Pit or the "Water-Gin" Pit, from the fact of a water-gin or water-wheel having been formerly employed at it to work the pumps. Mr. Joseph Monkhouse, of Gilcrux, who was present when this old pit was re-opened, says it must be nearly 100 years since it last worked. He arrived at that conclusion from information supplied to him at the time of re-opening the pit, by an old man, then 90 years of age, and who had worked in it. In the old shaft they found two columns of wooden pumps, about 8 inches diameter inside, and 3 inches thick. One set was made of staves, the other had been bored out of solid trees. Both sets were hooped, and they extended from the bottom to the top of the pit, which was about 30 fathoms deep. The working barrels were of cast iron. These pumps, it will be seen, resemble very closely those advertised for sale at Weary Hall Colliery in 1782. In the Water Gin Pit they also found a number of wooden spades, the handles of which were attached to the blades, and the latter were tipped with iron. A number of waistbands with chains attached were found as well. They had evidently been used in drawing the tubs of coal along the drift. The sole of the main workings were covered with cross sleepers of wood set close together, apparently to facilitate the trailing, as rails were not then in use. The method of working the coal was that of "pillar and stall," the pillars being very small, in some places not more than 9 feet by 6 feet, and they seem to have been all left in the mine. The roads were very narrow, some of them being only four feet wide.

In 1862, a serious fire broke out in Wellington Pit, Whitehaven, which continued to burn for a considerable time until the sea was let into the mine. It is also worthy of mention in connection with the Whitehaven Colliery, that until about nine years ago the old-fashioned baskets were actually in regular use for raising coal at William Pit. That pit was then superseded by the present Henry Pit, which is fitted up according to modern ideas. The old baskets held about 12 cwts. of coal, and they were landed on to trams at the top and bottom of the pit by a most ingenious contrivance designed by William Golightly about 46 years ago. Except that the baskets had to be fixed to and detached from the rope by hand, the arrangement was entirely self-acting and most expeditious in working.

Among the improvements effected in working the coal under the sea since the Henry Pit was started, is the substitution of engines moved by compressed air for the numerous horses that were formerly employed underground. Within the last twelve years mechanical ventilators of the Guibal pattern have replaced the old-fashioned furnace.

The coal produced in Cumberland between 1854 and 1882 is given below; the quantity exported at certain times between those years is also shown, as are also the dates at which the principal railways were opened:—

Date.	Railways Opened.	Coal Exported.	Total Coal Raised.
1840	Maryport and Carlisle	.....	.....
1844	Whitehaven Junction	.....	.....
1847	Cockermouth and Workington	.....	.....
1853	.....	555,216	.....
1854	.....	580,241	887,000
1855	.....	.....	809,546
1856	.....	.....	913,981
1857	.....	.....	942,018
1858	.....	.....	920,137
1859	.....	.....	1,041,890
1860	.....	.....	1,171,052
1861	.....	.....	1,255,644
1862	.....	.....	1,330,287
1863	.....	.....	1,327,368
1864	Cockermouth, Keswick, and Penrith ...	.....	1,380,795
1865	.....	.....	1,431,047
1866	.....	.....	1,490,481
1867	.....	.....	1,512,514
1868	.....	675,632	1,378,026
1869	.....	670,584	1,410,808
1870	.....	670,421	1,408,235
1871	.....	603,661	1,423,661
1873	.....	.....	1,747,064
1874	.....	.....	1,102,267
1875	.....	.....	1,226,737
1876	.....	499,993	1,399,603
1877	.....	507,550	1,515,783
1878	.....	495,999	1,392,773
1879	.....	584,559	1,459,170
1880	.....	514,035	1,680,841
1881	.....	512,265	1,769,213
1882	.....	460,882	1,747,317

These figures show so clearly the state of the coal trade during the time which they embrace, that, for present purposes, further comment on its development in recent years is unnecessary.

The companies working coal at the present time (September, 1884), and the situation of these pits, are as follows:—

Name of Colliery.	Where Situated.	Owner's Name.
Bolton	Mealsgate... ...	Cumberland Union Bank.
Allhallows	Mealsgate... ...	Allendale Coal and Lime Co.
Brayton Domain ...	Aspatria	John Harris's representatives.
Crosby and Gilcrux...	Bullgill	Lonsdale Iron and Steel Co.
Dearham Main ...	Dearham	Dearham Main Colliery Co.
Ellenborough ...	Maryport	Maryport Iron and Steel Co.
Flimby	Flimby	Flimby Colliery Co.
St. Helen's	Workington ...	St. Helen's Colliery and Brick Works Co.
Seaton Fire Clay ...	Workington ...	Joseph Cope & Co.
Broughton Moor ...	Broughton Moor...	Flimby Colliery Co.
Gill Head	Workington ..	Richard Graves.
Camerton	Camerton... ...	R. S. Mutch.
Dovenby	Dovenby	Dovenby Colliery Co.
Clifton	Clifton	West Cumberland Iron and Steel Co.
New Banks	Greysouthen ...	Marron Brick Co.
Dean Moor	Dean Moor ...	Mr. Summerson.
Oatlands	Oatlands	Moresby Coal Co.
Walk Mill	Walk Mill ...	Moresby Coal Co.
Asby	Asby	Exors. of late W. Irving.
Montreal	Moor Row ...	John Stirling.
Harrington	Harrington ...	James Bain & Co.
Wythemoor	Workington ...	Dr. Richmond.
Whitehaven	Whitehaven ...	Lord Lonsdale.
Whitehaven	Whitehaven ...	Whitehaven Firebrick Co.
Bowthorn	Cleator Moor ...	Whitehaven Hæmatite Iron and Steel Co.

The number of persons employed in the coal industry of Cumberland in 1854 was 3,579, and in 1880 it was 5,944.

In recent years necessity has arisen for the consideration of the important question as to whether coal will be found at an economically suitable depth under the extensive area of Permian rocks which occupy north-west Cumberland, and several attempts have been made to settle the problem, but hitherto success has not attended these efforts. This is mainly owing to the nature of the works carried out, which were altogether inadequate.

LEAD AND COPPER, &c.

There does not appear to be any record of the early working of the ores of these metals, but there can be very little doubt that both lead and copper mines were worked long before the time of which any account of them is available.

In the year 1209 or 1210 the monks of Furness Abbey acquired an extensive estate in Cumberland, which included the Manor of Borrowdale. The grant does not make mention of any minerals whatever, so that presumably there were not any then known to exist in that locality. The manor, having fallen to the Crown on the dissolution of the monastery, was granted by James I. to William Whitmore and Jonas Nerdon, who, by a deed dated 28th November, 1614, sold it to Sir Wilfred Lawson and thirty-six others, reserving the plumbago mine.

In 1564 a patent was granted by Queen Elizabeth to Thomas Thurland and Daniel Heckstetter "to dig, search, try, sort and melt all manner of mine stores of gold, silver, copper, and quicksilver." But it appears from Fuller that mines had been carried on some considerable time before that. Speaking of the copper mines in Newlands, he says, "They lay long neglected (choked in their own rubbish) till renewed about the beginning of Queen Elizabeth, when plenty of copper was here afforded both for home use and foreign transportation."

From the State Papers (Domestic Series) the following information relating to these mines is obtainable. On the 1st August, 1566, Thomas Thurland wrote to Sir William Cecill that a copper mine had been discovered at Newlands, which was the best in England.

On the 7th October, 1566, Thomas Thurland writes to Sir William Cecill that the smelting houses and furnaces at Keswick are erected.

On the 29th August, 1566, the Earl of Northumberland, by his officers, objected to the working of a mine called "Copper Plate." This mine is situated near Grange in Borrowdale.

On the 29th September, 1567, Thurland writes that they have at length attained to making fine and perfect copper. At that time there were six furnaces at Keswick.

On the 29th September, 1567, Daniel Heckstetter and Hans Lowver intimated that they had succeeded in making copper from the ore at Boroughdale (Borrowdale).

In 1568 negotiations were going on with Mr. Curwen for a piece of ground at Workington on which to erect a wharf. There appears to have been some difficulty in procuring coal then.

Camden in his "Britannica" (1586) speaks of Keswick as "a little market town, ... long since noted for mines (as appears by a certain charter of Edward the Fourth), and at present inhabited by miners." It would thus seem that Keswick was famous for its mines more than 400 years ago.

The copper works at Keswick were destroyed by Cromwell in 1650 or 1651, and most of the miners were slain or dispersed during the Civil Wars. Prior to this period copper had been wrought in the hills about Coniston, whence it was sent to Keswick to be smelted, as appears by two letters in 1684 from Mr. D. Davies, "Concerning several copper mines in answer to some queries by Dr. Lister, F.R.S."* The writer says:—"The first work that was found and wrought in by the Dutchmen in Coniston Fells is called 'Low Work.' It has a stulm or shaft to draw water from the mine. When they ceased working it was left good, and had been wrought from the day to the evening end of the said works, 40 fathoms or thereabouts, the seam or vein of copper ore then was left above three-quarters of a yard thick of good ore, which seam or vein went from the evening end to the morning end of the said work, and was esteemed an extent of 200 fathoms, wrought as the vein went, and was, when left, all near of a breadth or thickness. The copper ore in this work was mixed with some silver or lead ore. The second work is called 'White Work,' or 'New Works,' about 40 fathoms from the first, which was found a little before the works were given over, being wrought about 10 fathoms deep; the seam then left was about 22 inches of good copper ore. The third work is called 'Toung Brow,' a little distant from the last, being wrought about 30 fathoms, and the seam about 2 feet thick of like ore. The fourth work is called 'God's Blessing,' or 'Thurdale Head,' being wrought about 20 fathoms, and is about a mile from the last mine; the thickness of the seam of ore above a yard when left off, and thought, by the workmen, much of it to be gold ore, it having been highly prized by their masters at Keswick. The fifth work is called 'Hen-Cragg,' a mile from the last, and wrought about two fathoms; a small seam, but excellent ore, and expected to prove a large seam. The sixth work is called 'Sunny Work,' at Lever's Water, at the water-side, a little above that Hanch Clocker's Work, a little above that George Towers and William Dixon's Work. Bartle Clocker's Work, near the last, Richard Tower's Work, then Hanch Mires' Work, being all seven works, and lie together and about a mile from the fifth work aforesaid, and wrought about 10 or 12 fathoms, the seam of ore about 16 inches thick, the stone very soft, the ore very rich,

* "Philosophical Transactions," 1693.

and much of the said ore green, and was very much prized by the head masters at Keswick. The seventh work is called 'Grey Cragg Beck,' found by William Dixon, the seam about 18 inches thick. . . . The eighth work is called 'John Dixon's Work,' in Brunfell, then newly found, and wrought about 2 fathoms, and esteemed the best ore except God's Blessing. The ninth work is called 'Wide Work,' or Thomas Hirn's Work, wrought about 6 fathoms, and left a seam about 26 inches thick of very good ore. The tenth work is called the 'Three Kings of Tilberthwaite,' being three works, and wrought above 40 fathoms apiece. The seams being above 14 inches of very good ore, but a little troubled with water. These are all the works that have been wrought in Coniston Fells."

West, speaking on the authority of an old document, prepared soon after the Civil Wars, and preserved at Rydal Hall, refers to the above works as follows:—"About 140 workmen were employed in these works, and the ore was carried on horses' backs to the smelting house at Keswick, about 20 miles distant from some of the works. The ore was raised at different prices, according to its goodness, from 2s. 6d. to 8s. per kibble, every kibble being near a horse load. The ore was first beaten small, and washed and sifted, then weighed or measured. . . . Before the works were left off a proposal was made for erecting a smelting house at Coniston, as more convenient for building houses and better supplied with wood and peat, with the convenience of an iron forge, than at Coniston, being only distant 7 miles from the seaport at Pennybridge, 5 miles of which were by water down the lake, and 2 miles of land carriage on a good road."

In 1667, according to Merret,* the Borrowdale Black Lead Mines appear to have been in existence; and in 1683 Pettus,† in speaking of them, says that the pencils made from the wad were enclosed in fir or cedar.

Denton, in his MS. History of Cumberland (1688), observes that the smelting-houses at Keswick were all destroyed, and the miners most of them slain in the Civil Wars. "The works," he says, "have never since been set on foot, albeit there be still great store of copper and lead in these mines."

Robinson, writing in 1709, says, "In our survey of the mountains of Newlands we found eleven veins opened and wrought by the Germans, all distinguished by names given to them, as Gowd-Scalp (now Gold-

* "Pinax Rerum Natural," 1667.

† "Fleta Minor," by J. Pettus, 1683.

Scalp), Long Work, St. Thomas's Work, etc., of all of which veins the richest was that they called Gowd-Scalp. We found the vein wrought 3 yards wide and 20 fathoms deep above the grand level, which is driven in a hard rock a hundred fathoms, and only with pick-axe, hammer, and wedge, the art of blasting with gunpowder being not then discovered. For securing of this rich vein, no cost of the best oak wood was spared; and for the recovering of the soles under the level was placed a water-gin, and water was brought to it in troughs of wood upon the tops of high mountains, near half a mile from the vein. . . . . This rich vein, and several more in the mountains of Newlands, are now laid open and recovered by His Grace the Duke of Somerset, and likewise smelt-houses, furnaces, and all other conveniences are made ready by His Grace for setting forward a great work. But it may be presumed that the discouragement His Grace met with, which at present hath put a stop to so noble a project, was his meeting with an ignorant operator, who understanding not the nature of the ore, burnt and destroyed 50 tons of the best Gold-Scalp ore, without the production of one pound of fine copper." This writer also refers to the Borrowdale Black Lead Mines.

Clarke, in his "Survey of the Lakes," speaking of the copper works at Keswick, says, "The Dutch who came with William Prince of Orange, about 1690, began the work again, and, although temporarily driven from it in 1715, they stayed until the place was not worth the working."

In 1777, Nicholson and Burns writing of Borrowdale, say, "In this parish, in Seatoller Fell, is that famous mine of black-lead or wad." . . . Bishop Nicholson in a letter to Dr. Woodward, August 5th, 1710, speaks of this mine as follows:—"Having lately had notice of the opening of our wad mines above Keswick, I hasted (with some others) to see a curiosity which I never hitherto had an opportunity of viewing, and, if this were omitted, I was never likely to have another. . . . On the first opening of the old level, in the latter end of June last, great discouragements appeared; for no search having been made in thirty-two years, they found that some pilfering interloper had carried on the old work, till they had lost it in the rock. Upon the 3rd July (the day before we got thither) a new belly was happily discovered above the forehead of the old man, which proved so rich that in less than twenty-four hours they had filled several sacks with fine and clean-washed mineral."

Little, if anything, seems to have been done in Newlands from the above date for certainly more than eighty years; for Hutchinson, writing in 1794, although referring to the mines, does not say they had been worked since their abandonment by the Germans. Speaking of the mines near Caldbeck, this writer says, "It appears that so long as the reign of

Queen Elizabeth mines were opened and worked on Caldbeck Fells, though the ore is said to have been carried to the great works at Keswick to be smelted." In the reign of Elizabeth, when the Earl of Northumberland seemed determined to carry on the works here and at Newlands with spirit, he was checked by an ill-timed law-suit respecting the royalty of these mines, the issue of which was in favour of the Crown, which, however, has never derived any advantage from it, unless it was an advantage to deter subjects from dabbling with the ore. . . . . Once more, however, hopes are entertained that at length the mines in these fells may turn to good account. Wm. Rowe, Esq., is said lately to have discovered on the south side of the High Pike a rich vein of lead ore, which, at about 3 feet below the surface, runs for at least a mile in length 18 inches thick, and even seems to increase. Levels are now driving, and a smelting-mill erecting; and if these works succeed, as there is every reason to hope they may, it will be a very great encouragement for the new attempt on the copper mines at Hay Gill." In a foot-note to the above, the following statement occurs :—"Our correspondent informed us on the 3rd October, 1794, that a large copper vein had been discovered upon the north side of Carrock Mountain. Trials had formerly been made in several places. It is 5 feet wide, and the copper worth £30 to £40 a ton. It was supposed that two workmen got 80lbs. one afternoon last week. The present lessees are Wm. Rowe and Co., of Liverpool."

Speaking of Ennerdale, Hutchinson says, "At Low Mere Beck, in the township of Kinniside, a lead mine was opened in the year 1791. It was first discovered in the apertures of the shaken rocks, and at the first working had a very promising appearance, the metal being good and the situation convenient; but by the negligence or unskilfulness of the workmen the vein was lost, and the undertaking given up after a short trial."

Mr. J. Postlethwaite,* speaking of the Borrowdale Plumbago Mines, says that a pipe, which was discovered in 1778, produced 417 casks, containing 70 lbs. each of the plumbago, which at 30s. per lb., the price then current, would represent £43,785. A deposit, found in 1803, yielded 31¼ tons, which at the same price would realize £105,000. During this year (1803) £3,795 was expended in working the mine, and the net profit realized was £92,690. In 1812, Winkle's pipe was discovered, and 87 casks of the best quality and 495 casks of inferior plumbago were obtained from it. The 87 casks of the best quality alone realized £9,136. After this date the search for the mineral was successful, and the price increased rapidly. The produce of a deposit found

* "Mines and Mining in the Lake District," 1877.

in 1829 was sold at 35s., and one found in 1833 at 45s. per lb." Since then very little graphite has been obtained, although several parties have worked the mine.

In Lyson's "Magna Britannica" (1816), there are the following references to lead and copper mines in Cumberland :—"About the year 1756 the old works at Goldscope were opened at great expense by Mr. Gilpin, but the undertaking proved unsuccessful. About the year 1806 a copper mine was opened about half-a-mile from Goldscope by Mr. Shepherd, who holds a lease under the Earl of Egremont. For about three years this mine produced about 150 tons of good ore annually, but the quantity has since very much diminished, and there is at present no prospect of better success.

"Copper mines have been worked at Borrowdale, near Ulpha, on Caldbeck Fell, and at Buttermere.

"A lead mine has been worked for three or four years on Caldbeck Fell, and, it is said, with considerable success, but we have not been able to ascertain to what extent. There are three lead mines working at Newlands, but with very little success."

Parson and White,* writing in 1829, make the following observations on the lead and copper mines :—*Caldbeck Fells.*—"There are many veins of lead here, but only a few of them are worth working. Driggith vein is the most valuable that is known. It was worked long ago by the lord of the manor, but owing to his deficiency in the art of smelting, he suspended the mine, after having sustained a great loss. Having laid idle about thirty years the mine was leased and re-opened in 1810, by some Carlisle and other gentlemen, who continued to work it till 1822, during which time they employed from thirty to forty pickmen, who raised yearly about 500 bings† of ore, every five bings of which yielded one fother of lead and about 45 ozs. of silver ; but in some instances as much as 62 ozs. of silver were extracted from one fother of lead, and frequently upwards of 50 ozs. The ore is hard and steel grained, and is very difficult to smelt, being strongly impregnated with sulphur and antimony. Besides the blue steel-grained lead ore there are green, yellow, red, brown, and white in the same veins, also manganese and the most beautiful yellow, blue, and green copper ores, several tons of which were dressed and sold in 1823, at about £15 per ton. The Driggeth Mine is now held under a lease by T. R. G. Braddyll, Esq., of Conishead Priory, in Lancashire; but it is now extremely poor. The smelt mill attached to this mine consists

* *Op. cit.*

† A *bing* of lead ore is 8 cwts., a *fother* of lead is 21 cwts.

of two ore hearths, one roasting and one refining furnace. Many veins have been wrought here, as appears from the number of old "bail hills" where lead ore has been smelted in different parts of these fells, upon one of which, it is said, a family once lived in a hut, and coined silver money from the produce of the old mine called Silver Gill, till they were discovered, and obliged to abscond. . . . At Carrock there was formerly a very rich copper vein (containing also lead ore) but it was soon worked out. There are two poor lead mines at the north and south extremities of Saddleback, but they are both abandoned on account of their poverty, so that nothing can be more untrue than the old hackneyed proverb which says: —

"Caldbeck and Caldbeck Fells
Are worth all England else."

Portinscale.—"A small quantity of lead ore is raised here." *Newlands.*—"At Huithwaite is a lead mine, where immense quantities of ore have been raised, but it is now very poor. The ores here got are the sulphuret or common galena, the white and brown carbonates, and occasionally the green phosphate of lead. Dalehead Mine was wrought a few years ago by the late Mr. Sheffield, mineral agent to the Duke of Devonshire, who obtained considerable quantities of rich grey, purple, and green malachite ore, but after erecting a smelt mill, and incurring other heavy expenses, the work was given up."

In or about 1822, John Taylor and Sons, of London, commenced to work the present Coniston Mines, which have been wrought continuously ever since, with the exception of a few months when they were given up by the old company and taken over by the present lessee nine years ago. Since 1822 about 100,000 tons of copper ore have been raised from these mines. The highest output for any one year was 3,847 tons, which was raised in 1866. What is known as the Deep Mine is now about 205 fathoms below the adit. About the same time that operations were commenced at Coniston, the mines at Tilberthwaite were taken in hand by the same company, but after raising about 411 tons of ore they were abandoned in 1831, and nothing more appears to have been done at them until 1867, except the driving of a long horse level. Between 1867 and 1875 from 700 to 800 tons of ore were obtained from these mines, and they were again abandoned.

Before the Furness Railway was extended to Coniston in 1859, the ore from the Coniston mines was carted to the pier near Coniston Hall, and then carried down the lake to Nibthwaite, whence it was carted to Greenodd for shipment.

The Goldscope Mine having probably remained idle for about 130 years, except for the short time it was wrought by Mr. Gilpin in 1756,

was again opened by Wm. Clemence and Co. in 1847, but was soon abandoned by them, and in 1848 Messrs. Clarke and Co. took the mine. They commenced operations on the old copper lode that had been previously worked by the Germans, but were not successful. They continued the adit on the vein for about 60 fathoms, and in that length only got about 75 tons of copper ore. In prosecuting this drift, and after driving the distance just mentioned, they, in September, 1852, struck a splendid lead lode, which they at once commenced to work, and abandoned the copper vein. The lead lode was very rich, in some places yielding as much as 8 tons of galena per fathom, and although the ore occurred merely as a "pipe" at the intersection of the lead and copper lodes, yet it continued to yield ore in large quantities until about 1864. From that time it became poorer, and in 1867 it was abandoned, the depth then being about 92 fathoms below the adit. In 1858 about 535 tons of galena were sold from the mine, and the average annual produce for ten years was over 400 tons.

When Messrs. Clarke and Company commenced operations they found in the adit level just below the Panholes an old water-wheel 16 feet 3 inches diameter, and some old wooden pumps 4 inches square. They had evidently been used for the purpose of keeping clear of water the sump which was put down in the sole of the adit by the old men. Whether they belong to 1756 or to the time of the German occupation is not known, but from Robinson's remarks on the mine it is probable they belonged to the latter period.

During the time Goldscope was working the same company were engaged upon a small lead mine at Castlenook, but it never yielded very much ore. They also worked the Yewthwaite Mine from which, between 1853 and 1856, they raised 163 tons of galena. For the next eight years very little was done to this mine, but in 1863 ore was raised again, and between that time and 1871 about 1,685 tons of galena were raised. The mine afterwards passed into the hands of Mr. H. K. Spark, of Darlington, but very little was done to it after the above date.

Before the Cockermouth, Keswick, and Penrith Railway was opened in 1864, the ore from these mines, as well as from others in the same neighbourhood, was carted to Cockermouth Station.

In 1848 the Brandlehow and Barrow Mines were taken by the Keswick Mining Company. Both mines had been previously worked, but very little of their previous history is known; it appears, however, that some of the workings in each mine have been driven by "plug and feather." The use of gunpowder in mines was introduced into England about the year 1670, in a copper mine at Ecton, in Staffordshire; so that it is probable

both Brandlehow and Barrow were worked more than 200 years ago. Very little was done by the new company at Barrow, but they carried out extensive works at Brandlehow, and a considerable quantity of galena was raised from that mine, but not to any commercial advantage. Both mines were abandoned in 1865, and remained closed until about a year ago, when they were taken by a new company and are being opened out again.

The Force Crag Mine was first opened by Messrs. Walton and Co. about forty-seven years ago as a lead mine. They continued to work it for about thirty years and then it was abandoned. After standing idle for a time it was recommenced as a Barytes mine; but it did not work many years before it was stopped again, and has since remained idle.

Many other mines besides those referred to have been wrought in the Lake District within the last forty years; but a description of their particular operations would not throw any further light upon the course of this class of mining, which in these districts, owing to the severe competition of foreign ores, has of late years been steadily on the decline.

In 1882, according to the Mineral Statistics, only two mines were at work in these districts, and they yielded the quantities of ore shown below:—

	Chalcopyrite. Tons.	Galena. Tons.	Blend. Tons.
Woodend Mines, Threlkeld	—	297	708
Coniston Mines, Coniston	666	—	—

In the museum at Keswick there are some old hammer-picks which were found near the copper-plate mine in Borrowdale. In all probability they were used by the Germans who worked these mines. The length of the tool is $5\frac{1}{4}$ inches, the hammer-face is $\frac{7}{8}$-inch by $\frac{6}{8}$-inch. The eye is $\frac{6}{8}$-inch by $\frac{7}{16}$-inch now, although it is probable that it was larger originally, as it now much corroded. Similar tools have been met with in the Silver Gill Mine in Caldbeck Fells, which indicate that the Germans also worked these mines. An old pick-hammer, of the same shape as those just described, but longer, was found in Goldscope Mine. It is $9\frac{1}{4}$ inches long, and the eye is only $\frac{1}{2}$-inch square, but it is corroded.

It may be worth placing on record that at Coniston Mines until a few years ago chains were used instead of ropes for winding purposes, even from the Deep Mine.

The following paper on "The Carboniferous Rocks of Cumberland and North Lancashire, or Furness," by Mr. J. D. Kendall, C.E., F.G.S., was read:—

THE CARBONIFEROUS ROCKS OF CUMBERLAND AND NORTH LANCASHIRE, OR FURNESS.

By J. D. KENDALL, C.E., F.G.S.

These rocks have been already somewhat minutely described by the writer in his previous communications to the Institute, but no special attempt was therein made to correlate the different members found in one district with those met with in the other, or with the corresponding formations of other parts of the kingdom. It is therefore proposed to deal with that part of the subject now, and in order to render it as clear as possible, it may be necessary to go over some of the old ground again. That, however, will be done as briefly as possible, and only for the sake of completeness in the observations.

The development of the Carboniferous rocks of the two districts, as set forth in previous papers by the writer, is as shown below :–

	Cumberland.	Furness.
a.—	Coal Measures.	———
b.—	Millstone Grit.	———
c.—	———	Yoredale Rocks.
d.—	Carboniferous Limestone.	Carboniferous Limestone.
e.—	———	Lower Limestone. Shales.
f.—	———	Basement. Conglomerate.

This division of the rocks in the two areas seems to have been generally adopted hitherto, but further reflection on the subject, after the acquirement of a much greater amount of information than he previously possessed, has led the writer to a modification of this division, in the manner and for the reasons hereafter detailed.

LOWER LIMESTONE SHALE, CARBONIFEROUS LIMESTONE, AND YOREDALE ROCKS.

In the "Hæmatite Deposits of West Cumberland,"* it was pointed out for the first time that the group of rocks, which in West Cumberland has hitherto gone under the name of the Carboniferous limestone, consists, in the Whitehaven district at least, of several persistent beds of limestone separated from one another by beds of sandstone and shale.

The form of development is practically the same from Egremont to Ullock, and wherever the formation is complete the same number of

* Trans., Vol. XXVIII., p. 109.

main limestone beds are discernible. This will be best understood by reference to Plate XIII., in which is given a number of complete sections of the limestone formation as it has been ascertained to exist at the different parts of the district indicated.

Description of the Formation as exhibited by the Sections.

First, or Top, or Langhorn Limestone.—Consists of one mass of limestone, divided into beds, and varying in thickness from 30 to 60 feet. Sometimes the upper part of the bed, especially about Winder, is silicified, and its thickness then appears, for this reason, to be less than it really is.

Between the first and second limestones sandstones and shale intervene. They vary in thickness from 10 to 14 feet.

Second Limestone.—Also consists of one mass of limestone, and varies in thickness from 14 to 24 feet.

Between the second and third limestones there is from 40 to 60 feet of rocks, which are sometimes entirely sandstone, at other places they are all shale; but more frequently it is found that they consist of sandstone and shale together.

Third Limestone.—This bed, like the two above it, consists entirely of limestone, and ranges in thickness from 10 to 16 feet.

In the "Hæmatite Deposits of West Cumberland," this bed was included with the one immediately below (now the fourth limestone), from which it is divided by only $2\frac{1}{4}$ to $6\frac{1}{4}$ feet of shale, but as this shale bed, although thin, is very persistent, it is more convenient, as well as more correct, to consider the limestones between which it lies as separate beds.

Fourth, or Clint's Limestone.— This bed varies from 235 to 310 feet in thickness. In some parts of the district it consists almost entirely of limestone, but in others it is split up by thin beds of shale, which, however, are very inconstant, but generally they may be said to increase in number and thickness towards the north-east. Some parts of the limestone of this bed are at times very silicious; the rock then assumes that character which is locally known as "Whirlstone." Towards the north-east sandy beds appear in it. This is so at Winder.

Under this limestone there is from 14 to 24 feet of shale usually, but occasionally it is shale and sandstone.

Fifth Limestone.—This bed, like the last, is split up by thin beds of shale, but they are very inconstant. It ranges in thickness from 50 to 70 feet.

Between the fifth and sixth limestone there is from 14 to 24 feet of shale, or shale and sandstone, and sometimes thin beds of limestone. These dividing beds are more variable than any of those above, but still they are sufficiently persistent to be always traceable.

Sixth Limestone.—Also contains a few thin partings of shale, and varies in thickness from 54 to 70 feet, except at Lamplugh, where it reaches the uncommon thickness of 105 feet.

This bed is separated from the seventh or bottom limestone by a few variable shale beds, which, in the neighbourhood of Egremont, became so thin, that the sixth and seventh limestones may there be said to form one bed, although towards the north-east they are distinctly separated, as will be seen on reference to Plate XIII.

Seventh, or Bottom Limestone.—Contains a few partings of shale, and varies in thickness from 40 to 182 feet. So far as proved, this bed is thinnest at Lamplugh and thickens gradually towards Egremont. Within the more important parts of the hæmatite area the variations in thickness are less than those just mentioned, there being a rapid thinning of the bed towards the north-east after leaving Eskett.

Under this limestone there is a bed of shale, mostly of a red colour, but sometimes it is grey, at others nearly black. Occasionally, as in the neighbourhood of Egremont, it has in some of its layers quite a conglomeratic character. The bed is very thin in the neighbourhood of Yeathouse and Salter; but from there it seems to thicken gradually both towards Lamplugh on the one hand and Egremont on the other. Everywhere within the Whitehaven hæmatite district, that is to say, over an area of about seven square miles, this shale forms the base of the Carboniferous rocks and reposes on the upturned and eroded edges of the Skiddaw Slate, facts which go to show that the Carboniferous rocks of that area were deposited on a plane of marine denudation. Whether that plane extended across the Lake district, as has been thought by some, will be considered later on.

The problem now to be solved is, what are the seven limestones that have just been described, with their intervening beds of shale and sandstone? Are they the equivalent of the Carboniferous limestone of Furness and of Yorkshire, or to what do they correspond? To answer these questions it is necessary to have more information, and to meet that want Plate XIV. has been prepared, the line of the different sections in which is shown on Plate XVII. where, in addition to the sections already given in Plate XIII., there are sections at Hodyoad near Ullock, at Ann's Hill near Cockermouth, at Blencow, and in Allendale and Weardale. In the opposite direction sections are given of the rocks at Egremont and in Furness.

The whole of these sections were obtained either by boring or sinking, except where otherwise stated on Plate XIV., that is to say, except the upper part of the Cockermouth and Blencow sections. By combining the results of these sections as correlated in Plate XIV., the unexpected conclusion is arrived at that a large part of that formation, which in West Cumberland has hitherto been called Carboniferous limestone, is the equivalent of the Yoredale rocks of Alston, Allendale, and Weardale. It has always seemed a curious thing to the writer that Yoredales should exist in Furness and at Alston Moor, and yet be absent in West Cumberland which abounds in Carboniferous rocks; moreover, so far as can be seen, that area has passed through exactly the same physical conditions and changes as both of the former localities. The conclusion pointed out on Plate XIV. however reconciles this matter.

It will be seen that the large development of Yoredale rocks in the Alston and Weardale districts is due to the north-easterly expansion of the sandstones and shales which separate the different beds of limestone in the upper part of the so-called Carboniferous limestone of the Whitehaven hæmatite district, and mainly to the expansion of the bed which separates the first and second limestones. That expansion commences somewhere about Brigham. By reference to Plate XIV., it will be seen that from Moor Row to Ullock there is, at the different places where sections are taken, very little difference in the thickness of this bed; but beyond Ullock, in a north-easterly direction, the first place where the bed can be seen is in the hill-side opposite Papcastle Station. Its full thickness is not exposed, but enough is visible to show that it is much thicker there than at Ullock. A section of the bed, so far as it is exposed, is as follows :—

Top Limestone.

	Ft.	In.
Shale	4	6
Coal		4
Sandstone		4
Fireclay	3	2
Sandstone	26	0
	34	4

Base not visible.

The next place where a view of this bed is obtained is near Gilcrux. In the bed and banks of the stream which runs down by High Flat it is exposed for about three-quarters of a mile; and it is quite clear from the exposures that it is very much thicker there than at the last point where

it was examined. At Lowling, the bed has been proved by boring to have a thickness of 168 feet, although its upper part was absent at the place where the bore was put down.

Leaping over a considerable space of intervening ground the bed is again seen in the River Peterill, along the course of which it may be traced interruptedly for a distance of 1¼ miles on the line of dip, that is, from Blencow Hall to below Catterlen Hall, its thickness here being undoubtedly greater than at Gilcrux, and, in fact, rapidly approaching that which it has at Allendale and Alston Moor. At Gilcrux and Lowling, as well as at Blencow, the bed consists exclusively of alternating sandstones and shales.

In the sandy and shaley bed, between the third and fourth limestones, a slight expansion also takes place towards the north-east, but a more considerable change in that direction arises from the splitting up of the fourth limestone of the Whitehaven district by shales and sandstone, as shown in Plate XIV. At Moor Row and Parkside this bed consists almost entirely of limestone. At Eskett, two well-defined beds of shale appear near the middle of it. There are traces of these beds at Parkside, but they are very small at that place. When Lamplugh is reached they are considerably thicker. At Ullock they have become partly arenaceous. This latter change seems to be established when Cockermouth is reached, for, from that place onward, the beds consist partly of shales and partly of sandstones, and are subject to a gradual expansion on to Alston Moor and Weardale. In effecting these changes the most rapid rate of expansion is about 4½ feet per mile in the Argillaceous and Arenaceous beds, and the greatest rate of thinning in any one bed of limestones is about 1½ feet per mile.

The fifth bed of limestone of the Whitehaven district continues with but very little change on to Blencow. Thence it becomes split up as shown in Plate XIV. by sandstones and shales.

Accompanying the north-easterly expansion of Arenaceous and Argillaceous beds that has just been pointed out, there is a diminution in the thickness of the limestones, which will appear from an inspection of Plate XIV. The extent of these changes will, however, be best illustrated as follows :—

AGGREGATE THICKNESS OF YOREDALES.

	Whitehaven District. (Moor Row.) Ft.	Allendale and Weardale. Ft.
Arenaceous and Argillaceous beds ...	87½	705
Limestones	390½	183
Totals	478	888

The correlation of the limestones and the Yoredales of the two districts are as shown on Plate XIV., as follows :—

Whitehaven District.		Alston, Allendale, and Weardale.
First limestone, equivalent of	...	Fell Top limestone.
Second limestone	...	Inconstant beds, between Fell Top and Little limestones.
Third limestone	...	Little limestone.
Fourth limestone	...	Great limestone. Four-fathom limestone. Three-yard limestone.
Fifth limestone	...	Five-yard limestone. Scar limestone. Tyne bottom limestone.

The absence of Yoredale rocks between Egremont and Furness prevents the changes that have taken place in their physical character in that direction from being followed in the way that has been done with the rocks in the opposite direction; but there is little doubt that the correlation shown in Plate XIV. is correct, and that the five uppermost limestones of the Whitehaven district are the equivalent of the black shales and interbedded limestones of Furness. These five limestones will hereafter be referred to as Yoredales.

It appears, therefore, that only the sixth and seventh limestones in the Whitehaven district are the equivalent of the Carboniferous limestone of Yorkshire and Furness. By reference to Plate XIV. it will be seen that these limestones increase in thickness from Lamplugh to Egremont, and, at the same time, the shale beds separating them become less. In all probability these intervening beds disappear altogether at a very short distance on the south-west side of Egremont. The limestones will then resemble, in their form of development, the Carboniferous limestone of Millom and Furness, of which, doubtless, they are an extension, and into which they eventually lead by a continuation, under the Permians, of that expansion which is observable between Lamplugh and Egremont. The average rate of expansion of the two beds, where observable, is about 8 feet per mile, but in the bottom bed alone it is over 20 feet per mile. Between Egremont and Furness the increase in thickness must be at the rate of about 28 feet per mile. In the opposite direction the sixth and seventh limestones, or their equivalents, occupy but a very narrow belt along the western and northern flanks of the Lake District Hills as far as Hesket Newmarket, so that although there is probably an expansion in that direction, judging from the relative widths of the belt at the different

places, yet it does not appear to be great. But near Hesket Newmarket a more rapid expansion sets in and continues around the eastern side of the Lake district and on into Yorkshire.

The red shales underlying the seventh limestone in the Whitehaven district, as already pointed out, are thinnest in the neighbourhood of Yeathouse and Eskett, whence they thicken gradually, both towards the north-east and the south-west. These shales are in all probability the equivalent of the red shales and the limestones underlying the Carboniferous limestone of Furness, and of the soft red sandstone, frequently conglomeratic, which occupy a corresponding position in the Carboniferous rocks of Cross Fell and Alston. The rate of expansion between Eskett and Lamplugh is about 23 feet per mile. From Egremont, in the Furness direction, it must be about 30 feet per mile. These correlations will be best understood when exhibited in a generalised section as in Plate XV.

The basement conglomerate, which is present in Furness and at Great Mell Fell, near Troutbeck Station, as well as further eastward, and on to Roman Fell, probably thins away to nothing as it approaches Whitehaven from both sides as indicated in Plate XV.

MILLSTONE GRIT AND COAL MEASURES.

In Furness the grits do not appear to exist, unless the uppermost part of the sandstones and shales, which are usually considered Yoredales, may be so called. The rocks referred to are met with in the neighbourhood of Gleaston under the Permians. They have, however, only been proved by boring, so that not much is known about them. In the Whitehaven district the grits undoubtedly exist, but to what extent it is difficult to determine.

In his paper on "The Structure of the Cumberland Coal-fields,"* the writer did not attempt to fix the base of the coal-measures, for the simple reason that he felt considerable difficulty in doing so, but a reconsideration of the matter, with further information, has led him to form a definite opinion thereon.

The lowest seam of coal that has been extensively worked in the Cumberland coal-field is the Six-quarter coal of Whitehaven. This seam is known by a variety of names in different parts of the district, as indicated below:—

At Cleator Moor	it is known	as the	Low Bottom.
„ Harrington	„	„	Three-feet.
„ Workington	„	„	Hamilton.
„ Greysouthen	„	„	Lickbank.
„ Greenspot	„	„	China Band.

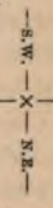
* Trans. Vol. XXXII., p. 319.

Below this seam very little has been done, and that at one or two places only. At Harrington two lower seams, known as the Four-feet and the Udale, have been worked over a considerable area. The Four-feet seam has also been worked to a small extent at Workington, where it was called the Virgin Band. It was worked too in a trifling way at Branthwaite. By means of boring at the foot of Wellington Pit it was proved to exist there, but it was not worked.

At Micklam Pit, Harrington, the Four-feet Seam is 27 fathoms below the Three-feet Coal, but its depth below that seam appears to increase from Micklam Pit both towards the north-east and the south-west, as shown below.

Depth of Four-feet Coal below Three-feet or Six-quarter Coal:—

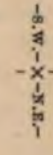
	Fathoms.
At Whitehaven (Wellington Pit)	47
„ Harrington—	
Micklam Pit	27
Henry „	36
Natty „	41
„ Workington (Jane Pit)	55



The Udale Seam occurs below the Four-feet Coal in the Harrington field at from 25 to 30 fathoms as under.

Depth of Udale Seam below Four-feet Coal:—

	Fathoms
Micklam Pit	30
Jane „	25
John „	28
Henry „	29



The strata between these seams appear to undergo a similar expansion towards the north-east and south-west to that which occurs in the rocks between the Three-feet and the Four-feet Coals, but the distance over which reliable information can be obtained as to the depth of the Udale below the Four-feet Seam is too small for any reliable conclusion to be drawn from variations in the thickness of the intervening strata.

At John Pit, Harrington, the Yoredale rocks were pierced at a depth of 30 fathoms below the Udale Seam, and, so far as is known to the writer, that is the only place at which the depth of those rocks below any known coal seam has been directly proved.

In the Whitehaven hæmatite district, on the east of the southern part of the Cumberland coal-field, numerous sections have been obtained of the rocks overlying the Yoredales, that is to say, of strata occupying the same

relative position as those which include the Four-feet Coal and the Udale Seam at Harrington, but they are not coal-bearing in the hæmatite district, or but rarely so, and only to a small extent. In the neighbourhood of Winder, as well as at Parkside and Bigrigg, alternations of sandstones and shales over 70 fathoms in thickness have frequently been passed through before reaching the Yoredale rocks, and in many cases there was not a trace of coal met with, although the rocks gone through should have included both the Four-feet Coal and the Udale Seam if those coals had maintained, relatively to the Yoredales, the position which they have at Harrington. Sections of this class, obtained at Crossfield and Parkside, are shown on Plate XVI. It becomes necessary, therefore, to determine whether this want of correspondence in the rocks of the two areas arises from the strata between the Udale Seam and the Yoredales at Harrington being subject to an expansion as they approach the Whitehaven hæmatite area, or from the thinning out of the Four-feet Coal and the Udale Seam in that direction. That these seams are inconstant is certain, as will appear from a consideration of a few facts obtained by boring. The Four-feet Coal is found at Gilgarron, where it has a thickness of about 4 feet; it also exists at Branthwaite, and is there about 3 feet thick, but it is dwindled down to about 12 inches near Whitekeld. At Aspatria No. 1 Pit it is absent; at Wellington Pit, Whitehaven, it was proved to be 3 feet 5 inches thick, and at John Pit, Harrington, it was 3 feet 4 inches. At the latter place the Udale Band was 4 feet thick on an average, but it was very variable both in size and quality according to the late Mr. Alvan Penrice. At Westgill End, High Harrington, also near Harrington Church, and at Hayes Castle, Distington, both the Four-feet Coal and the Udale Seam are wanting, although the measures otherwise are in their regular order. These facts go to show that both the Four-feet Coal and the Udale Band are very inconstant, so that it is not at all surprising they have not been met with about Parkside and Bigrigg as already mentioned.

Just above the Four-feet Coal at Harrington is a post of sandstone from 10 to 12 fathoms thick. This post is also met with at Gilgarron, Branthwaite, Whitekeld, and Winder, varying in thickness within the limits just mentioned, and having the Four-feet Coal below it at each place, though at the two latter places it is very thin and poor.

Having established the horizon of the Four-feet Coal at Winder, its position may also be indicated at Shaw, near Bigrigg, and at places intermediate to those two, as shown on Plate XVI. In support of the

ereon set forth it may be mentioned that at a few fathoms

below the Four-feet Coal at Harrington several thin beds of limestone are met with. These beds are also found in the same relative position at Winder and Shaw. (See Plate XVI.) Limey beds were proved, too, just under the position of the Four-feet Coal at Aspatria, and the borehole by which they were proved was, on that account, stopped, as it was considered that the Carboniferous limestone was near at hand.

The seam at Shaw, which the writer looks upon as the Udale, is 3 feet thick, but it appears to be absent at Crossfield, Parkside, and Winder, as shown on Plate XVI., although its position at those places is quite easily ascertained on a comparison of the sections.

It was pointed out above that the beds below the Three-feet Coal near Harrington expand both towards the north-east and the south-west, and now it appears from Plate XVI. that the same thing prevails in the Whitehaven hæmatite district, particularly in the beds between the Udale Seam and the top of the Yoredales. This might almost have been expected from what was ascertained in that area when dealing with the rocks below. There is not, however, in this case, proof over such a large area as there was in that; still there is quite sufficient, particularly when it is borne in mind that the results have been amply verified by a large number of sections obtained at intermediate points.

From the conclusions thus far reached it appears that the rocks lying between the Udale Seam and the top of the Yoredales are practically of the same thickness at Harrington that they are in the Whitehaven hæmatite area, and that it is not an eastward thickening of these measures, but a dying out of the coal in the rocks above them, which gives rise to the absence of coal in the rocks overlying the Yoredales at Parkside and Bigrigg, etc.

The only point, therefore, which now remains to be ascertained is, where is the top of the grits? Is it below the Udale Seam or above it? A careful consideration of the facts inclines the writer to the opinion that it is below, as pointed out on Plate XVI. The rocks between the Udale Seam and the top of the Yoredales consist mainly of coarse grits and shale, the latter increasing in thickness towards the north-east and south-west at a much greater rate than the grits. These rocks also include, at places, some thin beds of limestone and, very rarely, a thin coal or two. The bands of hæmatite and turgite occasionally met with in these rocks are probably due to the replacement of thin beds of limestone which originally existed in them. If the rate of expansion in these grit beds which is observed between Parkside and Winder should continue towards the north-east their thickness in Northumberland would be much greater

than it is usually supposed to be, so that probably the rate of expansion becomes reduced, as also in all likelihood does that of the beds above the Udale Band.

From the Six-quarter Coal down to the Udale Seam the strata are of the ordinary coal-measure type, only that sandstones are more abundant than in the measures above. Some of these sandstones are quite gritty, so too, in places, are the Arenaceous beds just *above* the Six-quarter Coal. In the railway cutting at Birkby, immediately under the Low Bottom Seam of Dearham, there is a bed of grit as coarse as any millstone grit in the district.

The rocks between the Six-quarter Coal and the Udale Seam may therefore be considered as partly of the nature of coal-measures and partly like the millstone grit, being, as it were, transition beds between these two formations. They may, therefore, for want of a more appropriate name, be called Lower Coal-measures.

The upper part of the coal-formation has been already fully dealt with in "The Structure of the Cumberland Coal-field," so that it is not intended to add anything further here on that branch of the subject, beyond this, that if the purple grey colour of the rocks which the writer classes as Whitehaven sandstone be simply due to Permian staining, as is held by some persons, it is a very remarkable thing that such staining never extends below any seams the identity of which has been proved with certainty.

The Carboniferous system as developed in West Cumberland may now be divided as below :—

	Greatest ascertained thickness in West Cumberland. Feet.
Whitehaven sandstone or Upper Coal-measures	778
Middle Coal-measures (including all the seams between the Metal Band and Six-quarter Coal at Whitehaven)	867
Lower Coal-measures (including the Four-feet Coal and the Udale Band)	433
Millstone grit	155
Yoredale rocks	540
Carboniferous limestone	228
Lower limestone shale	77
	3,078

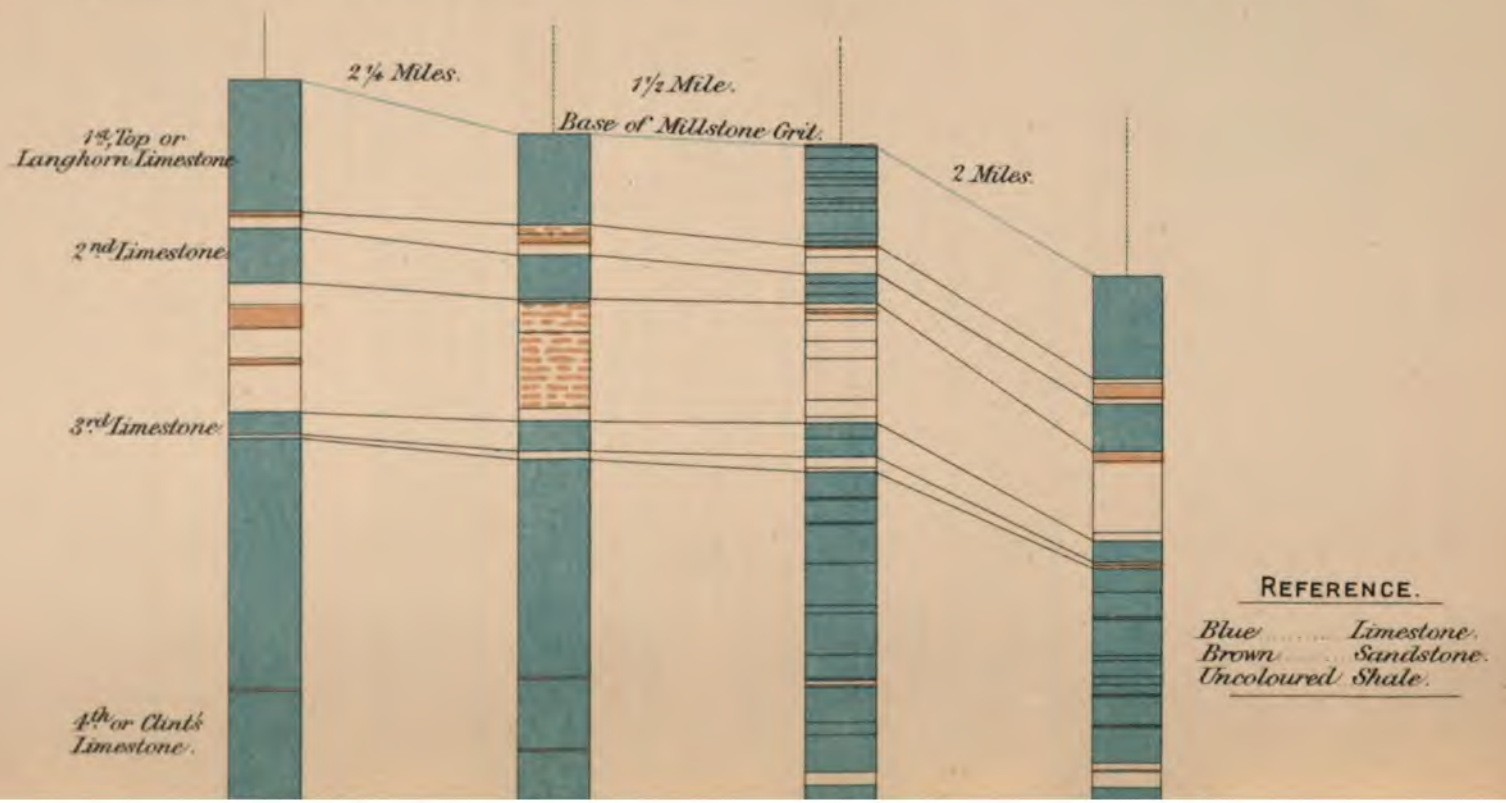
To fix exactly the level of any of the Cumberland coal-seams in the Northumberland rocks would require a much larger amount of information than is now available, but it is probably not very far from the fact to say that the Yard Coal of Cumberland is about on the same horizon as the Hutton Seam of Northumberland.

Before concluding it may be of interest to examine briefly the meaning of the north-easterly and south-westerly expansion of all the Carboniferous strata below the horizon of the Six-quarter Coal of Whitehaven. Obviously it indicates the existence of an island somewhere within the Silurian area of the Lake district at the time the expanding Carboniferous rocks were forming, by which the currents bearing the sedimentary materials were deflected, as indicated in Plate XVII. Facts of a different nature from those now brought forward but pointing in the same direction were mentioned* by the writer in a paper on the "Mineral Veins of the Lake district," recently read before the Manchester Geological Society. The opinion which is held by several good geologists, that the Carboniferous rocks once covered the Lake district would, therefore, seem to be ill-founded. According to those geologists, the base of the Carboniferous rocks, if continued in towards the Lake district, will pass over the tops of all the mountains within that area. But that is not so, at least in West Cumberland, as will appear from an inspection of Fig. 2, Plate XVIII. Even in cases like Fig. 1 on that Plate, where the Silurians are at present everywhere below the continued base line of the Carboniferous rocks, it cannot be said that these latter rocks once completely overspread the former, for it is evident that whilst denudation was lowering the ground under *c*, it was also taking away that below *d*, at the same if not at a greater rate, so that there must have been a time when the Silurians stood considerably above the continued base line of the Carboniferous rocks, as shown by the dotted line *c d*, Plate XVIII., Fig. 1, and they must, therefore, have prevented the assumed extension inland of the latter rocks in the way that has been suggested by some geologists, as mentioned above. This part of the subject might be followed much further, but the data are not sufficiently reliable for satisfactory work, because where the plane on which the Carboniferous rocks were deposited has been removed, its position may or may not be indicated by a continuation, in a straight line, of that part of it which remains intact.

The PRESIDENT said Mr. Kendall was not present, but any gentleman present could make remarks upon the paper and so direct Mr. Kendall's attention to matters which he could reply to when the paper was discussed.

* "Trans. Manchester Geological Society," Vol. XVII., p. 292.

To illustrate Mr. J. D. Kendall's paper "On the Carboniferous Rocks of Cumberland and North Lancashire, or Furness."



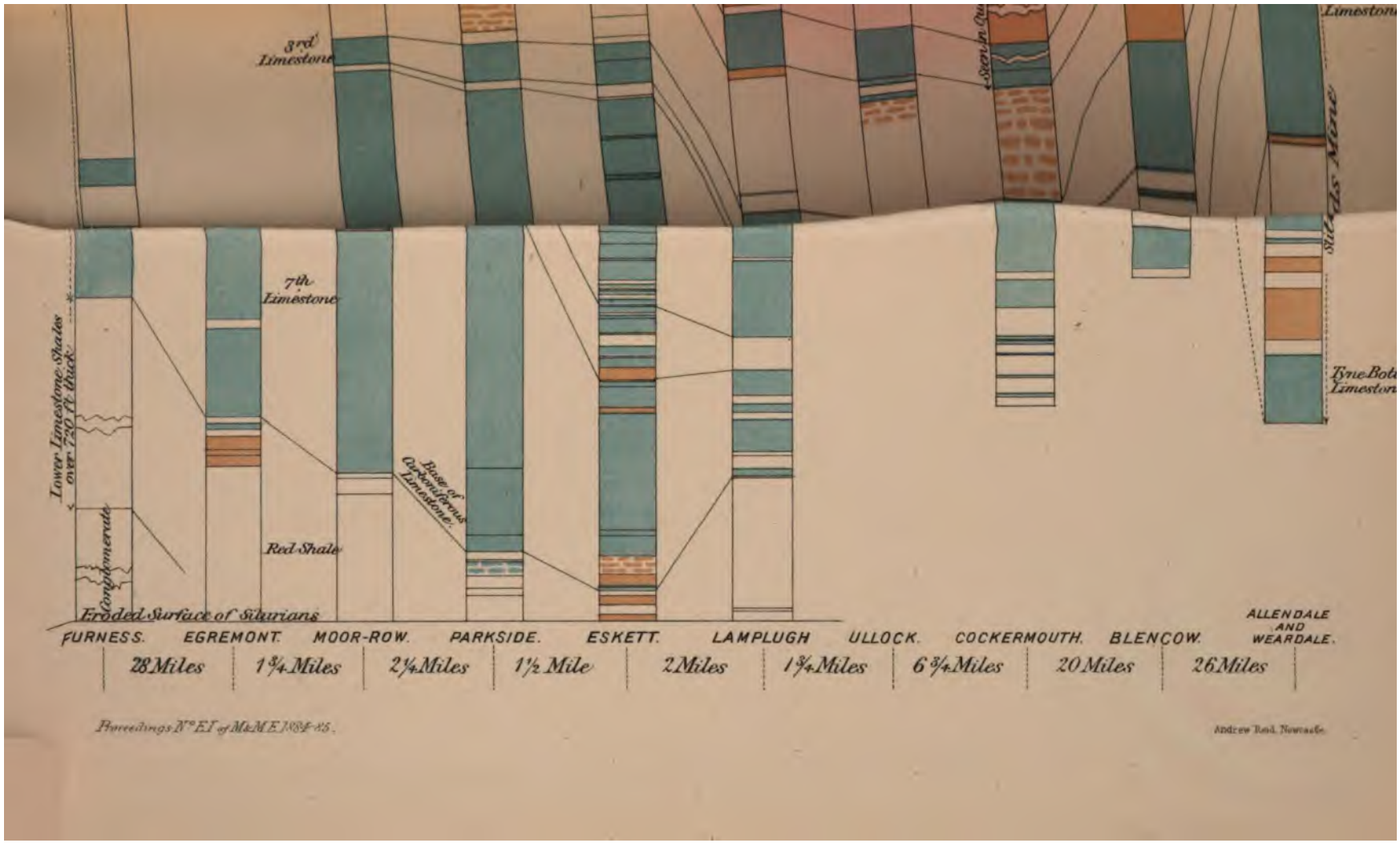
Scale 90 feet = 1 inch.

Proceedings N°E.1 of M&M.E. 1884-85

Andrew Reid, Newcastle

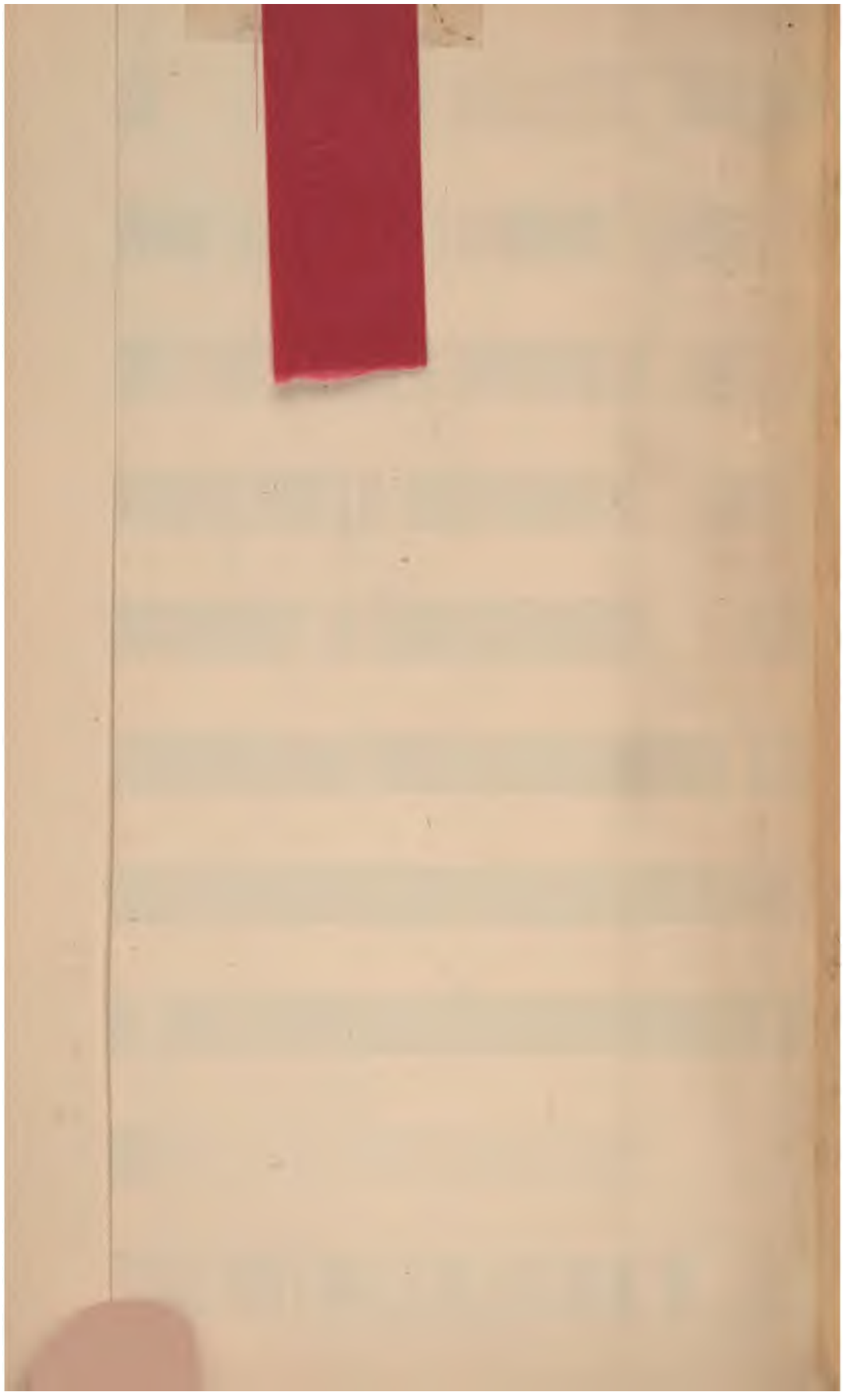
136

To illustrate Mr. J. D. Kendall's paper "On the Carboniferous Rocks of Cumberland and North Lancashire, or Furness."

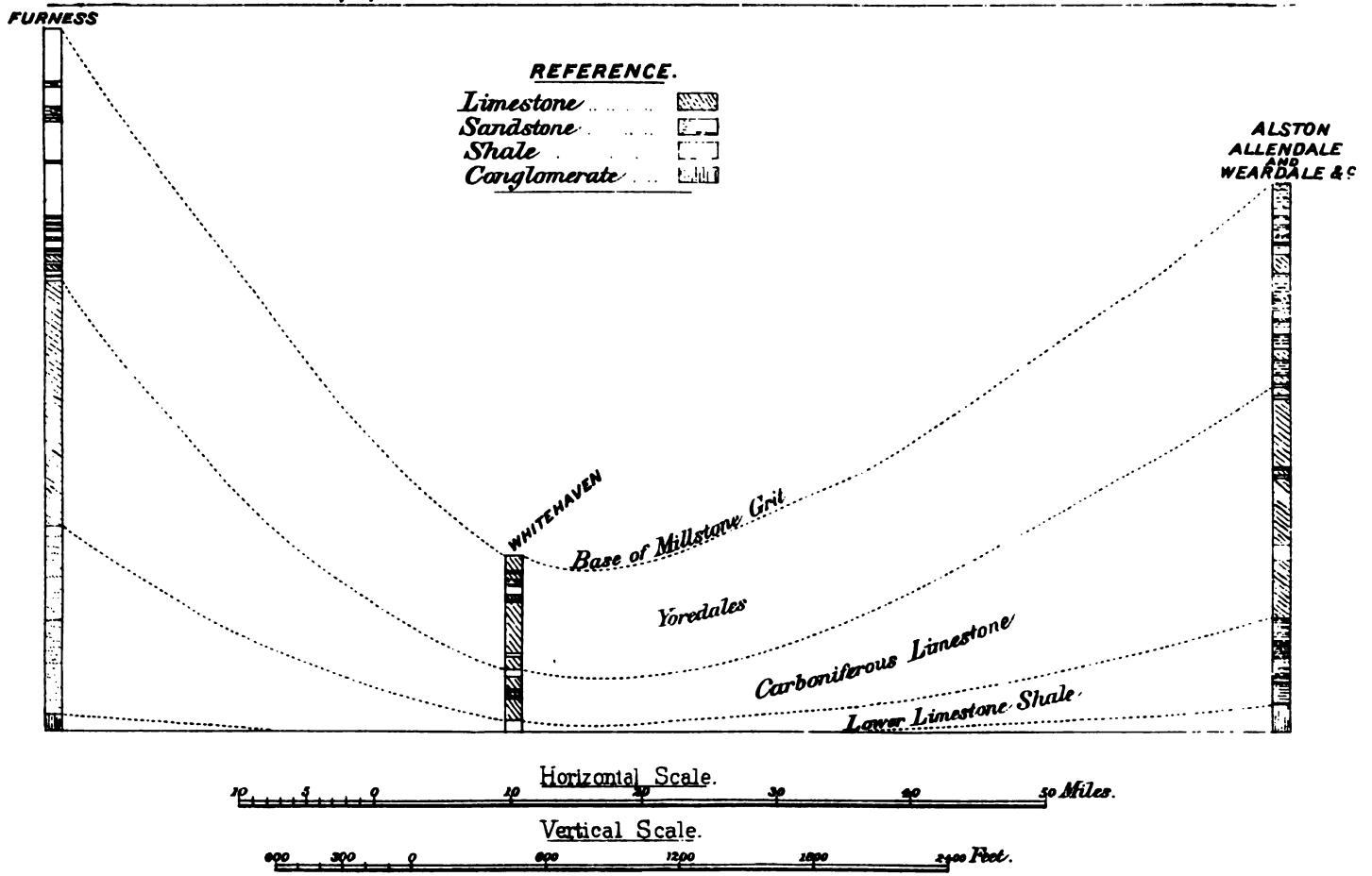


Proceedings N°E.I of M&M.E. 1884-85.

Andrew Reid. Newcastle.



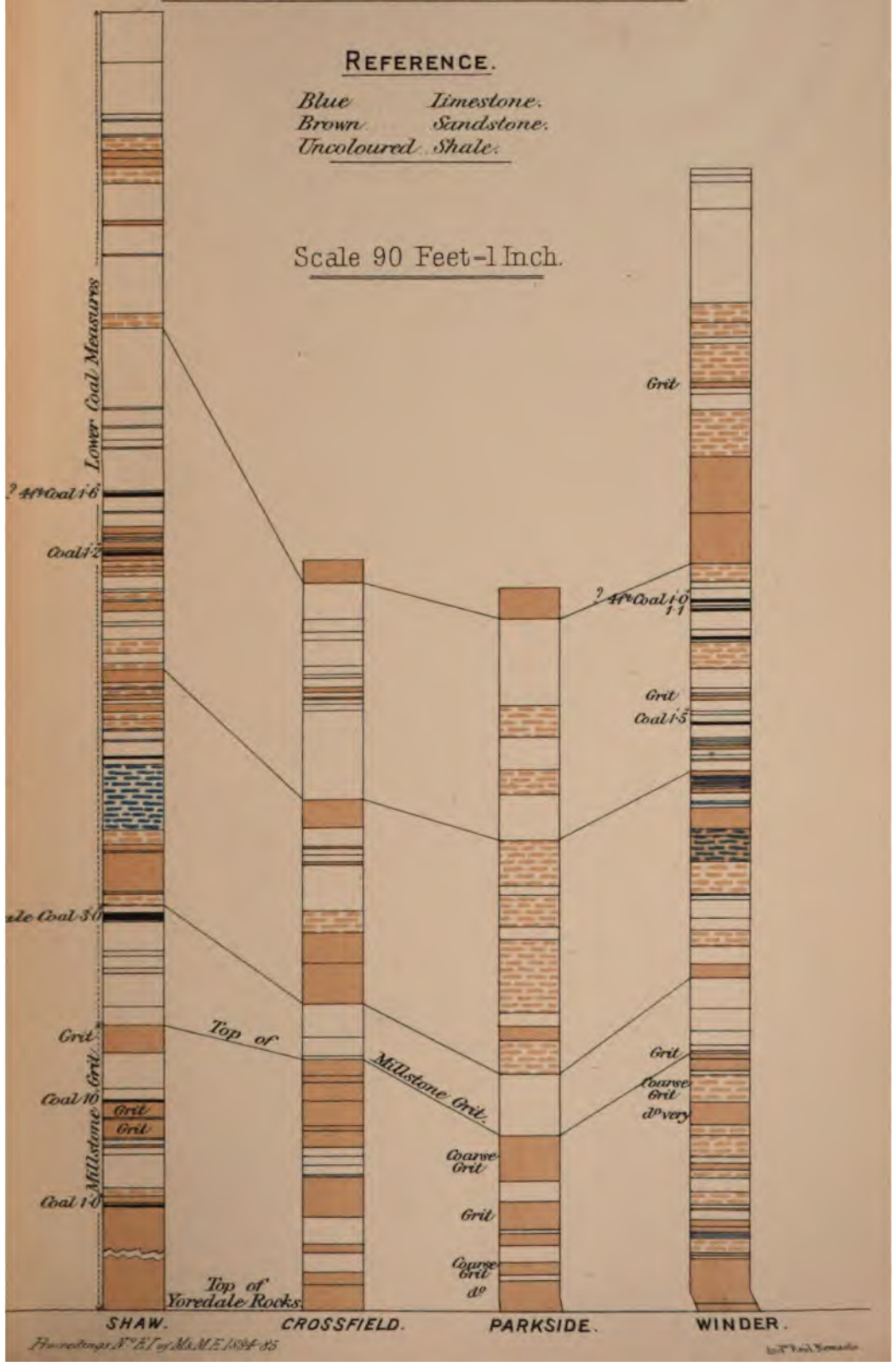
To illustrate Mr. J. D. Kendall's paper "On the Carboniferous Rocks of Cumberland and North Lancashire, or Furness".



131 c

136 d

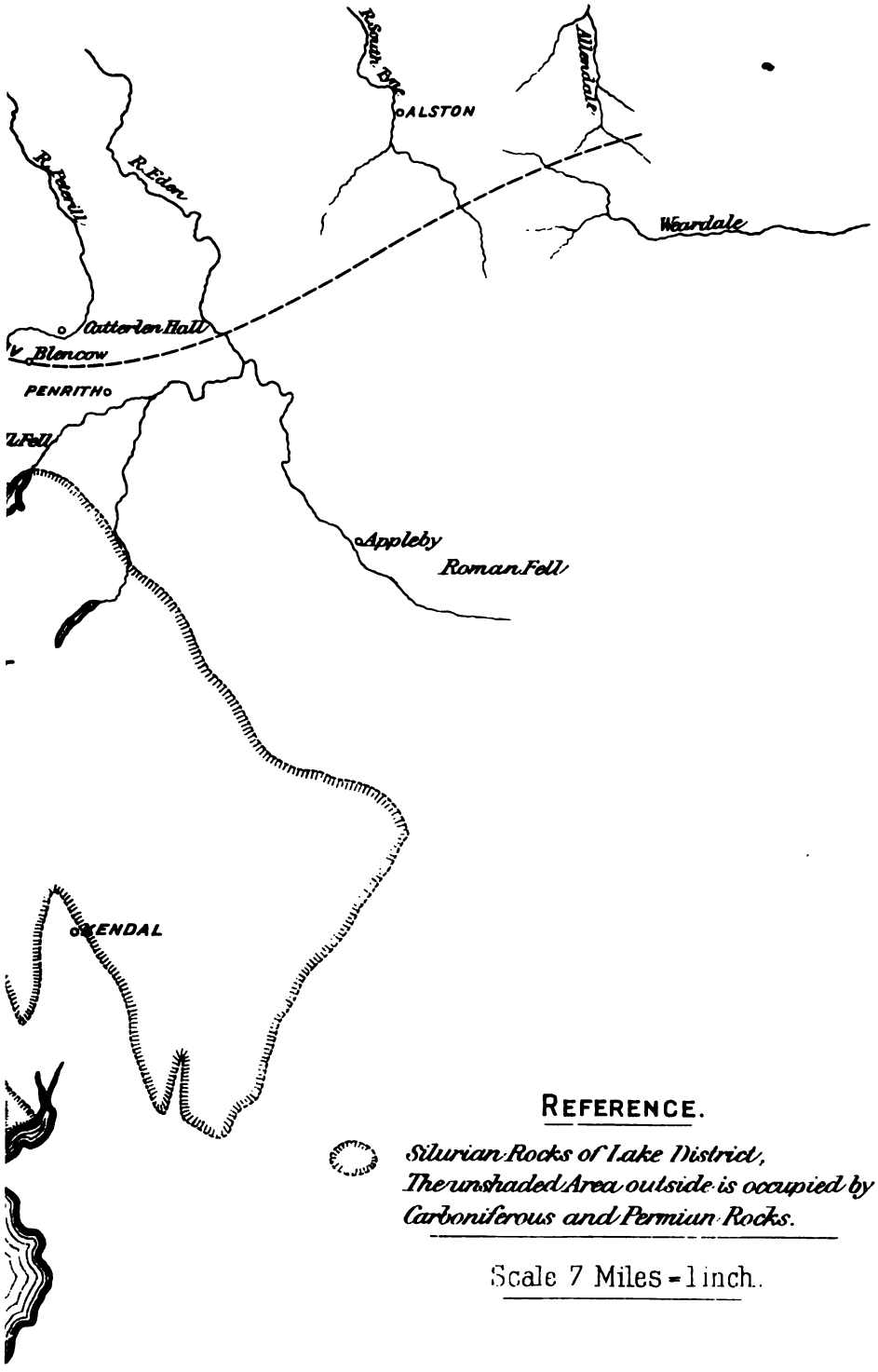
To illustrate Mr. J.D. Kendall's paper "On the Carboniferous Rocks of Cumberland and North Lancashire or Furness."



Proceedings N.C.E.I. of Mech. M.E. 1884-85

To illustrate Mr J.D. Kendall's paper "On the Carbonif
Deflection of Sediment bearing Current by Silurian Island during early Carboniferous times.
Lowling
Aspatria
Birkby
Gilcrux
LINE OF SECTIONS IN PLATE
MARYPORT
Ann's Hill
COCKERMOUTH
Papcastle Sta.
WORKINGTON
Brigham
Ullock
Harrington
Hodgrad
Distington
Owsen Fell
KESWICK
Lamplugh
Winder
Eskett
Yeathouse
Parkside
WHITEHAVEN
Crossfield
Moor Row
Shaw
Bigrigg
Heckbarley
EGREMONT
LAKE DISTRIC
IRISH SEA
Silecroft
ULVERSTON
FURNESS
BARROW
MORECAMBE BAY
Proceeding. No. E.I. of Mo.M.E. 1884-85

ous Rocks of Cumberland and North Lancashire, or Furness."



REFERENCE.

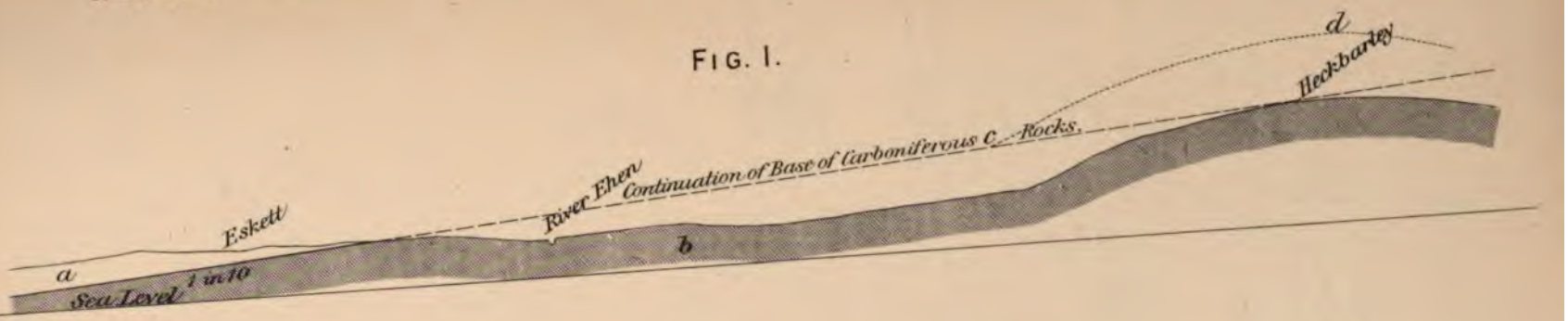
Silurian Rocks of Lake District,
The unshaded Area outside is occupied by
Carboniferous and Permian Rocks.

Scale 7 Miles = 1 inch.

Andrew Reid, Newcastle.

To illustrate Mr. J.D. Kendall's paper "On the Carboniferous Rocks of Cumberland and North Lancashire or Furness."

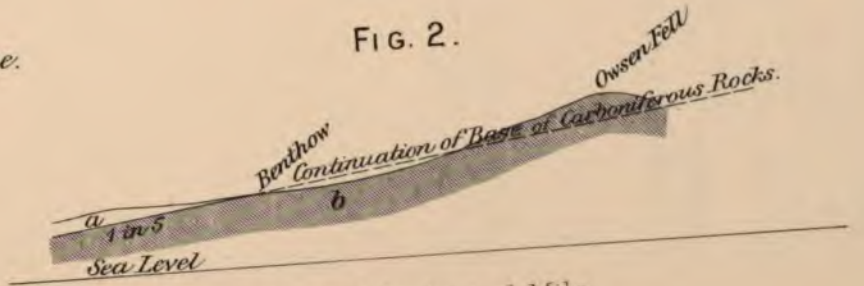
FIG. 1.



REFERENCE.

a. Carboniferous Limestone.
b. Skiddaw Slate.

FIG. 2.



Scale 3 Inches—1 Mile.

Lith. Reid, Newcastle.

Awarded Mus. Pract. Geol. Mech. Eng. 1884-85.

1351

Mr. E. F. Boyd said the consideration of the paper would be greatly assisted if a rough map was prepared showing the places mentioned in the paper. Members had no idea from the names what direction they took, or how they influenced the different sections and different strata named. He proposed a vote of thanks to Mr. Kendall for his paper, the preparation of which must have required an enormous amount of labour.

Mr. Bewick seconded the vote of thanks, and said that such a map as that referred to by Mr. Boyd was necessary. The paper was a comprehensive one and must have called forth lengthened and very careful observation on the part of Mr. Kendall. He was afraid there were few of them who could go into the subject unless they had a map.

The President said the Secretary would mention to Mr. Kendall the observations which had been made, and he hoped when the paper was discussed that such a map would be before them.

The vote of thanks was agreed to.

The following paper on "A New Calculator for working out 'Cost of Working,' 'Selling Prices of Coal' per ton, Percentages, &c.," by Mr. Emerson Bainbridge, was read :—

ON A NEW CALCULATOR FOR WORKING OUT "COST OF WORKING," "SELLING PRICES OF COAL" PER TON, PERCENTAGES, &c.

By EMERSON BAINBRIDGE.

The principle of slide-rules depends upon the properties of logarithms; these enable multiplication or division calculations to be performed by the simpler methods of addition and subtraction respectively. Thus, instead of multiplying or dividing numbers to obtain any required result or quotient, their logarithms are added or subtracted, and the remaining figures are the logarithms of the required answers. But this proceeding requires frequent reference to a table of logarithms, whereas, by the use of a slide rule, the time thus employed is saved and strict accuracy ensured. The latter is in fact nothing less than a mechanical arrangement by which the logarithms of any number are presented to the eye at a glance, and by a slight movement of the sliding part the most difficult of calculations is performed, and the required answer is obtained in a moment, and this without the possibility of error.

The properties of logarithms above referred to may be illustrated by a few simple formulæ, in which letters are used in the place of numbers.

1. Log. $(a \times b) = \log. a \times \log. b.$
2. Log. $(a \div b) = \log. a - \log. b.$
3. Log. $\left(\frac{a \times b}{c}\right) = \log. a \times \log. b - \log. c.$

If the logarithms of numbers are represented by spaces measured in proportion to the relative magnitude of those logarithms, and if, further, those spaces represent the numbers themselves and are marked as such, the groundwork of the slide-rule is the result. Then to multiply or divide any quantities it is necessary to add or subtract the spaces representing them, and the resulting space represents the required answer.

The sliding piece is for the purpose of performing these additions and subtractions of spaces.

This particular calculator is an adaptation of the ordinary "slide-rule," especially made for use at collieries. Plate XIX., Figs. 1 and 2.

The logarithmic divisions are arranged on a scale large enough (being more than four times the usual size) to enable the operator to work out sums to a greater number of decimal points than can be done by the ordinary slide-rule. The instrument consists of a rule, the numbers of which run on the top side from 1 to 10, and on the bottom side the same divisions are arranged so that the division 3 in the top scale is brought down under 1 of the top scale, the divisions 4 to 10; following after which are placed the divisions 2 and 3 of the top scale, as shown in Fig. 2. This division of the bottom scale enables a wide range of calculation being made without the slide having to be shifted when once set, a small metallic "teller," or index, being applied to the rule for the purpose of enabling the readings to be taken with greater accuracy. The examples given below indicate the convenience and despatch which attend the use of the calculator.

Take the case of a coal-mine producing, say, 5,479 tons in a week, where the items of expenditure are as follow:—

	£	s.	d.	Cost per Ton.
Hewing or getting	569	3	4	24·93
Yard work	128	2	9	5·61
Datal	35	11	2	1·55
Deputies	27	4	9	1·19
Haulage	150	12	3	6·59
Lamp men	9	6	5	·40
Ventilating roads	25	19	6	1·13
Bricklayers	18	13	2	·81
Onsetting	21	6	11	·93
New work	12	14	7	·55
Timber	122	9	0	5·36
Oil	14	17	1	·65
Sundries	51	2	9	2·24
Horse keep	40	0	6	1·79
Total	£1,227	4	2	53·73

The "cost per ton" of each of the above items is shown in the right-hand column and is worked out by the calculator in the following way.

Find the dividing figure 5,479 on the slide, and place it opposite to the figure 240 (pence in a pound) on the rule, and opposite each of the amounts (on the slide) shown in the left-hand column will be found the cost per ton in pence and decimals of a penny; thus, opposite the amount of £569 3s. 4d., the cost per ton of this item 24·93d. will be read upon the rule, accurate reading being facilitated by the use of the "teller."

Without moving the scale the other costs are read opposite each amount. The time taken to work and check these results by ordinary calculation would be about four times longer than the time taken by the calculator.

The calculator is also of service when the relative percentages of a number of different amounts have to be calculated. Thus, if the percentage of each item of cost in the following statements has to be arrived at, the calculator would be used as shown below.

Cost per Ton.			Per Cent.
24·93	...	...	46·40
5·61	...	...	10·44
1·55	...	...	2·88
1·19	...	...	2·21
6·59	...	...	12·27
·40	...	...	·74
1·13	...	...	2·10
·81	...	...	1·51
·93	...	...	1·73
·55	...	...	1·02
5·36	...	...	9·98
·65	...	...	1·21
2·24	...	...	4·16
1·79	...	...	3·33
53·73			100·00

Mode of using the calculator.—The total cost per ton being 53·73d., find this figure on the slide and place it opposite 100 on the rule, and opposite each of the numbers (on the slide) shown in the "cost per ton" column may be read the relative percentages.

In both of these calculations it will be seen that a special advantage possessed by the calculator is that it cannot err, the accuracy of the reading depending upon the care exercised by the user, hence the lost time which is occasionally caused by a small error in a single calculation in the usual mode of working out costs, is avoided.

The calculator is about 22 inches in length, and any questions in which a number of multipliers and divisors are involved can be worked out by it. Thus, in the case of working out horse-powers, the mode of arriving at the result is as follows, assuming that the whole calculation (including the working out of the area of the cylinder) has to be made.

Diameter of cylinder, 24 inches; length of stroke, 4 feet; strokes per minute, 40; average pressure of steam, 27 lbs.; then—

$$\frac{24 \times 24 \times \cdot7854 \times 40 \times 2 \times 4 \times 27}{33{,}000} = 118\cdot4 \text{ H.P.}$$

In this case the first figure is 24, and by placing the figure 1 of the slide opposite 24 on the rule the square of this number will be found on the rule opposite 24 on the slide. Place the edge of the "teller" to coincide exactly with this result, and move the slide again until the figure 1 coincides with the same edge of the "teller." Then opposite 7,854 of the slide is found the result of the calculation—24 × 24 × ·7854. Again place the edge of the "teller" to coincide with this result, place the figure 1 on the slide to coincide with the same edge of the "teller," and opposite the figure 320, *i.e.* (40 × 2 × 4) on the slide, the next result will be found on the rule. Place the edge of the "teller" opposite this result as before, and the figure 1 on the slide opposite the same edge of the "teller," then opposite the last multiplier, 27 on the slide, will be found the next result. Again place the "teller" on this result, and bring 33,000 on the slide to coincide with this, when the total result (118·4) will be found on the rule opposite the figure 1 of the slide.

The special features of the calculator are—

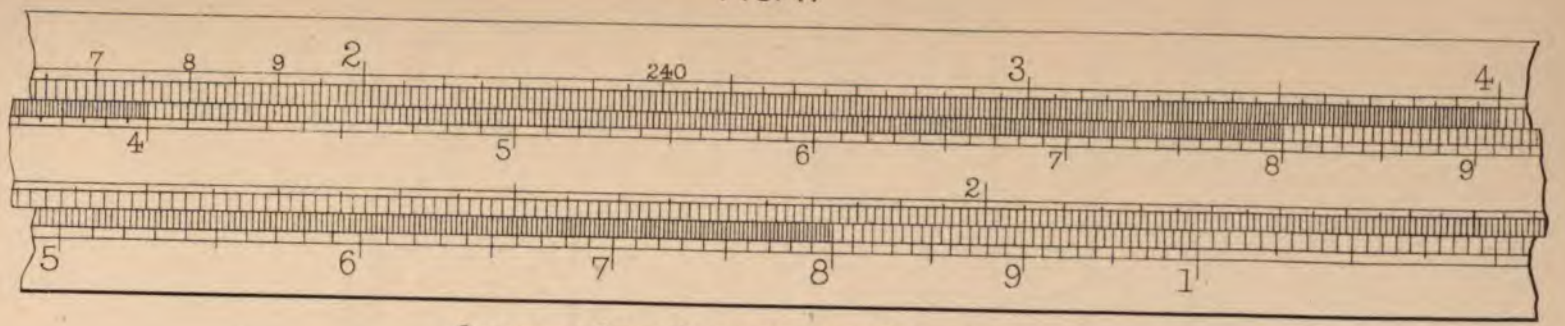
1. The large scale on which it is constructed, facilitating the accurate reading, and which is necessary to the special purpose for which the rule is constructed.
2. The use of the figure 240 as a constant multiplier.

The PRESIDENT proposed, and Mr. BEWICK seconded, a vote of thanks to Mr. Bainbridge for the paper, which was unanimously agreed to.

The PRESIDENT said he had received a note from Professor Merivale asking that attention should be called to the great variation that might sometimes be noticed in the difference of the simultaneous readings of two barometers, one at bank and the other in the workings of a mine; and he would be glad if any gentleman could furnish him with any information on the subject. When in London last week, he (the President) saw for the first time a very interesting thermometer in the coffee-room of the Inns of Court Hotel. It was an ordinary horizontal thermometer, delicately balanced somewhere above its centre of gravity, at an ordinary temperature. As the mercury expanded, it altered the centre of gravity and caused the tube to oscillate as would an ordinary scale balance, and the tube being provided with a pointer it indicated the temperature by means of a suitable scale arranged on a dial, so that it could be read right across the room. It was a very interesting instrument.

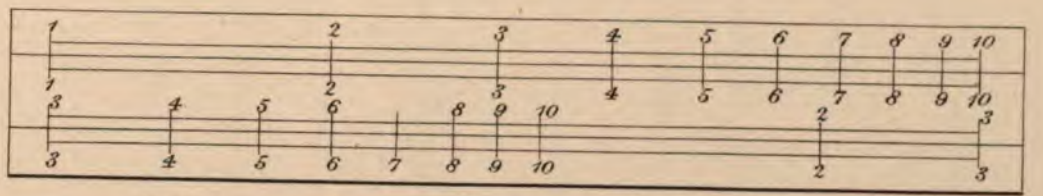
To illustrate Mr Emerson Bainbridge's paper "On a New Calculator for Working out Cost of Working &c."

FIG. 1.



SHOWING A SMALL PORTION OF THE RULE SERVING TO ILLUSTRATE SOME OF THE CALCULATIONS GIVEN IN THE PAPER.

FIG. 2.



SHOWING THE ARRANGEMENT OF THE ENTIRE RULE WITH THE MORE MINUTE DIVISIONS OMITTED.

Proceedings N.S. E.I. of M. & M.E. 1884-85.

1427
19

PROCEEDINGS.

GENERAL MEETING, SATURDAY, FEBRUARY 14TH, 1885, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

JOHN DAGLISH, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

The following gentlemen were elected, having been nominated at the last meeting:—

ORDINARY MEMBER—

Mr. JAS. STEVENS, M.E., Kaiping Mines, c/o H.B.M.'s Consulate, Tientsin, North China.

STUDENTS—

Mr. ROBT. RUTHERFORD, South Derwent Colliery, Annfield Plain, Lintz Green.

Mr. FREDERICK GEO. HOOPER, South Derwent Colliery, Annfield Plain, Lintz Green.

Mr. THOMAS YEOMAN, Loftus Mines, Loftus-in-Cleveland.

The following gentlemen were nominated for election:—

HONORARY MEMBER—

Mr. Principal GARNETT, M.A., Durham College of Science, Newcastle-upon-Tyne.

ASSOCIATE MEMBER—

Mr. J. MATTHEWS, c/o Messrs. R. & W. Hawthorn, Newcastle-upon-Tyne.

STUDENT—

Mr. WILLIAM ASHLEY SHUTE, Westoe, South Shields.

The following paper was read:—"On the Manganese Deposit of the Islet of San Pietro, Sardinia," by Mr. Edward Halse, A.R.S.M.; communicated by Professor G. A. Lebour:—

ON THE MANGANESE DEPOSIT OF THE ISLET OF SAN PIETRO, SARDINIA.

By EDWARD HALSE, A.R.S.M.

(Communicated by Professor Lebour, M.A.)

As the occurrence of manganese in exploitable quantity in trachyte is far from usual, the writer hopes a brief memoir on the San Pietro deposit, visited by him in January, 1884, may not prove uninteresting to the geologists and mining engineers of the north.

The island of San Pietro, to the south-west of Sardinia, is only some 28 miles in circumference and 6 miles across from east to west. On the eastern coast is the excellent port of Carlo Forte, 10 kilometres (6 miles) by sea from Porto Scuso, on the south-western Sardinian coast. From the latter small port there is a private mineral line 24 kilometres (15 miles) long to Iglesias. The whole of the lead and zinc ore wrought within a reasonable distance of the western littoral of that great mining district is ultimately shipped from Carlo Forte to English or continental ports.

San Pietro is of irregular shape, and being entirely composed of trachytic rocks the island has a very rugged appearance. The hills are mostly of bare reddish or gray rock, and the small vales and plains are clothed chiefly with shrubs, heather, and grass, trees being conspicuous by their absence. The climate is mild and very similar to that of the North of Africa.*

The manganese mine is on the western coast and properly consists of two concessions, Capo Rosso and Capo Becco, and of two "permissions of research;" the whole covering nearly 2,000 acres.

* On the 24th of January, at Carlo Forte (sea-level), the temperature in the afternoon was 62° F., the barometer (pocket aneroid) 30·2 inches; on level land, in the centre of the island about sunset, 60° F., barometer 29·7 inches; at Capo Rosso at dusk, 54° F., and barometer 29·925 inches. Heather was in bloom, and in the daytime lizards were darting hither and thither among the rocks.

The trachyte of this island has been described in much detail by La Marmora (*Voyage en Sardaigne*, 3e partie, description géologique, t. 1, c. 12, 1857). He recognised two main divisions of rock:—

(A.)—Trachyte Porphyry.

(B.)—Trachytic Tufa.

These two divisions are apparent in the section (Plate XXI., Fig. 1), which shows the *gisement* of the mineral bed as it crops out in the cliff near the "Galerie Camille" of the Capo Rosso Mine. The beds are described in the order in which they occur, commencing with columnar trachyte, which here forms the top of the cliffs.

(1.) Several yards of very hard trachyte of reddish base scattered with thin plates of dark green mica (biotite), and hard, dull, and opaque orthoclase and sanidine (transparent, vitreous, or pearly), and here and there discoloured by oxide of iron. A yellowish-green mineral is visible here and there (? sphene).

(2.) 3 feet 9 inches of trachyte with bluish-gray base, with similar minerals scattered throughout. This rock does not merge into the upper one; the line of separation is traceable, although there is no division plane.

The above are divided up into large columns or prisms by vertical joints, the chief of which course N. 58° W. (magnetic); but here the prismatic structure appears to be less developed than in the syenitic trachyte of Wolkenburg and Stenselburg,* probably because the rate of cooling was more sudden.

(3.) 1 foot 6 inches of reddish-white trachyte (?) paler and less hard than (1), spotted with similar minerals, and here and there stained with peroxide of iron and dioxide of manganese. It contains fragments resembling (1).

(4.) Yellowish-white trachytic tufa, 3 feet $2\frac{1}{2}$ inches thick, vesicular, and somewhat resembling pumice; some flakes of biotite are visible in it, as well as pale greenish and soft orthoclase. Here and there are little patches of black mineral, giving a manganese reaction with a borax bead. At the base are 3 inches of rock (*a*) resembling (3), but of finer grain and considerably softer; it contains also comparatively large pieces of greenish and opaque soft orthoclase, and black specks of manganese and decomposed biotite. Then come 3 inches of white tufa (*b*), of very fine grain, with a few black patches (MnO_2) and orthoclase visible to the

* In these localities the rock is divided into enormous vertical quadrangular, pentagonal, or hexagonal prisms, 33 yards high, and 1 to $1\frac{1}{2}$ yards in diameter. (*Mémoire sur le Siebengebirge et l'Eifel*, par M. R. Zeiller, Ann. des Mines, 6th Série, t. 19, p. 92.)

naked eye. With a lens it is seen to be scattered throughout with black specks, which before the blowpipe give a feeble iron reaction and are probably decomposed mica.

(5.) 2 feet of brown jasper of ribbon structure, with little ochre layers visible here and there, one of 6 inches being at the base.

(6.) 2 feet 6 inches more of jasper, brown above, red and yellow alternating below, and divided in the middle by 2½ inches of yellow ochre. This forms the roof of the bed.

(7.) Manganese ore, black to brown, consisting of a variable mixture of pyrolusite, oxide of iron, clay, etc. The average thickness, including partings, is about one foot.

(8.) Soft whitish clay, containing fragments of trachyte, etc., and forming the floor of the deposit.

(9.) Alternate layers of solid and clay-trachyte to the sea-level.

Mr. Rudler, F.G.S., has very kindly examined the trachytic rocks microscopically, and the results of his observations are given in an Appendix.

The following section (of which Plate XXI., Fig. 2, is a diagram) was seen by Baldracco at a place called Ripa della Tinta, and described by him in 1854 (*Cenni sulla Costituzione metallifera della Sardegna*):—

(1.) Compact trachyte, rusty gray passing to rosy, rarely porous, and scattered with small scales of mica, 12·46 feet thick.

(2.) Compact trachyte, yellowish-grey red, with little stains of a clear whitish-grey light-blue, minutely porous, and scattered with small scales of mica—solid, and very rough to the touch, 2·3 feet.

(3.) Whitish domite (? oligoclase trachyte), with minute particles of mica, 2·6 feet.

(4.) Trachyte (? trachytic tufa), reddish yellow, 5 feet, with a little layer of clay and red ochre at the base. The latter is little compact, does not effervesce in acids, adheres firmly to the tongue, dissolves easily in water, is pretty smooth to the touch, and through a lens steatitic saponaceous substances are recognisable in it.

(5.) Quartz-resinite of a deep flaxen colour, and slightly ochreous, 4 inches. At the base is 16 inches of yellow ochre, with veins sometimes of a rotten yellow colour.

(6.) Quartz-resinite, similar to (5), 2 inches.

(7.) Pulverulent oxide of manganese, only visible for 2 or 3 yards, and from 3 feet 3 inches to a few centimetres thick, the average being 18 inches.

(8.) Quartz-resinite confounded with other substances.

Total thickness of the section, 26 feet. The rocks below this are not stated, but they are doubtless the same as No. 9. of Fig. 1.

In this section the manganiferous and ochreous layers are much thicker than in the first, while the siliceous deposit is represented only by two thin layers of opal, showing that the amount of the deposit of minerals has varied somewhat considerably in different parts of the area although the order of deposition is the same. Jervis says the following varieties of jasper have been found on the western part of the island: blood red, ferruginous red (somewhat striped), dark-brown red, striped brown red (perfectly resembling silicified wood), brownish-yellow, deep green, and green, striped and of a resinous aspect; but Barelli described at least a dozen varieties from San Pietro, as long ago as 1835. (*Cenni di statistica mineralogica degli stati di Sen. Il re di Sardegna.*)

"The jasper of Carlo Forte is most exquisite; and for hardness, colouring, and vivacity of tint, it is eminently adapted for building purposes." (Jervis—*I tesori sotterranei dell' Italia*, 3d pt.)

The upper, newer, and columnar rock is hard, and varies from trachyte to trachytic porphyry (La Marmora). The minerals scattered through it are in a normal condition; moreover, there is no appearance of bedding, except at the base. The lower rocks, in which the manganese occurs, are layers of soft and tufaceous trachyte, containing angular fragments of the overlying hard rock. On approaching the manganese bed the mica changes in appearance, becoming duller in lustre, until it is finally unrecognisable, or recognisable only as black specks; the orthoclase becomes softer and changes in colour, until it seems to disappear.

La Marmora says, "The trachyte of this island in some points appears inclined very uniformly 25° to N.N.E., *i.e.*, the principal direction is E.S.E.-W.N.W." At Cala Sapone (San Antioco), the strike is the same, and the dip 18° to the N.N.E. At Capo Rosso the strike is N.W. (magnetic, 1884).

The trachyte, as will be seen by referring to the longitudinal section of the manganese deposit, Plate XXII., is folded, sometimes abruptly, in the direction of the strike. This folding necessarily gives the works of the mine an irregular appearance. The bed dips N.E. about 10°, but the dip is variable, the extremes being 6° and 23°.

The thickness of the seam was tested at the several points now being exploited and a sample was taken from each. The numbers in the following table correspond with the numbers on the plan :—

TABLE SHOWING THICKNESS OF THE SEAM.

Number on Plan.	Average Thickness.	Remarks
	Inches.	
1	...	The seam is split into two by a hard quartzose rock, the best ore is 6 inches thick; there is also hard rock between the lower layer of inferior ore and the clay floor. There is ochre in the jasper roof.
3–5	10	The seam is sharply folded, extremes 18 inches and 5 inches.
6	8	The seam is divided by a layer of jasper, extremes 12 inches and 5 inches.
7	7	The seam is divided by about 1 inch of clay, extremes 12 inches and 6 inches.
8	10	"Galerie Zero," dip here 20° E., temperature 70° F.
9	12	"Becco descenderie," dip 6° N.E., 98 yards above sea level. Total thickness = 15 inches, but there are two layers of ochre, &c., near the bottom, = 3 inches. At the entrance the ore alternates with yellow ochre.
10	12	"Galerie du Becco." In one place 14 inches, but containing from 3 to 4 inches of rock. Here there is red ochre below the ore, brown and red jasper above.

The average of the seam at these points, not including partings, is thus only about 10 inches. The ore varies in colour from brown to black, according as oxide of iron or oxide of manganese prevails, and is in general very friable. It is employed in the manufacture of ferro-manganese, and although its friability is apt to cause "scaffolding," it is cheap and practically free from phosphorus, and when mixed with Spanish ores of a higher percentage, it is found to work well in the blast-furnace.

The analyses on the following page are by Mr. Riley, F.C.S. The second analysis is an average of the nine samples enumerated above. It will be seen that the ore is only about half pyrolusite, a good proportion being oxide of iron. No. 1 analysis is an average of sample collected at three points considerably to the north of the others, where the ore is more or less solid, but apparently less thick (6 or 7 inches only). The large amount of free silica, and the comparatively high percentage of phosphorus in it (nearly one-half) must render this portion of the bed to a great extent inadaptable for the manufacture of ferro-manganese. In the concession of Capo Becco the mineral alternates with films of ochre, and thins out somewhat, the dip and strike in this (S.E.) direction being more regular. The bed of manganese, as it crops out here and there, can be traced in

a N.W. and S.E. direction for some miles. When absent its removal is mainly the result of denudation. A few faults are met with underground but they are of insignificant character.

Number of Analysis ..	1.	2.	3.	4.	5.
Class of Ore	Best.	Best.	Seconds.	Seconds.	Seconds.
Silica	26·35	8·0	10·1	7·20	8·40
Dioxide of Manganese	42·20	47·87	29·25	30·95	31·55
Oxide of Manganese	5·43	5·81			
Peroxide of Iron ...	10·76	19·10	19·10	20·30	19·12
Alumina	·95	2·26	3·5	5·41	4·40
Baryta	3·85	3·71	3·5	Not estimated	Not estimated
Lime	1·82	1·0	1·6	2·1	2·0
Magnesia	·55	·9	Not estimated	4·79	Not estimated
Phosphoric Acid ...	1·04 (P=·45)	·29 (P=·12)	·05	·06	·085
Sulphuric Acid ...	·16	Traces.	...	...	...
Moisture	1·29	2·89	26·00	22·44	19·9
Combined Water ...	3·78	6·48	Not estimated	Not estimated	Not estimated
Oxide of Zinc ...	·23	·65	Not estimated	Not estimated	Not estimated
Potash	1·66	1·40	Not estimated	Not estimated	Not estimated
	100·07	100·36	93·10	93·25	85·455
Manganese	30·89	34·76	19·00	20·00	20·50
Iron	7·53	13·37	13·37	14·21	13·38

In the following table, chiefly compiled from Jervis (*op. cit.*), the occurrence of manganese ore in trachyte in other parts of Sardinia is compared with the San Pietro bed and with veins of psilomelane in the so-called "trachytic conglomerate," near the Drachenfels (see Dr. Carl Zerrener, *Die Braunstein*, 1861, p. 59.) :—

TABLE.

Province.	Locality.	Mode of Deposit.	Mother-Rock or Country.	Nature of Mineral.	Associations.	Percentage of MnO_2	Remarks.
Cagliari..	Capo Rosso, Capo Becco (San Pietro)	Bed, 9 to 19 in. thick	White decomposed trachytic tufa(?Tertiary)	Earthy friable pyrolusite, sometimes hard and massive, psilomelane, stalactitic, and botryoidal—*rare*	White clay, red and yellow ochre, calcedony, and ribbon jasper	47·00*	Used in the manufacture of ferro-manganese
,,	Bosa	Bed, 19in. thick ...	As above (Tertiary)	Black massive pyrolusite	Chalcedony, jasper, &c.	58·80	
,,	†Bosa (Sas Coroas)	Fissures, 5 feet thick	,, ,,	Crystalline pyrolusite	... ...	...	Very pure, used for chemical works
,,	Gonnessa ...	Thin beds, 6½ feet thick	Underneath trachyte	Massive pyrolusite ...	Opaque white crystalline quartz	...	
,,	Sindia ...	Veins (?)	Trachyte and limestone	Hard pyrolusite ...	Quartz	...	‡At the plane of contact between the two rocks
,,	Porto Scuso...	(?)	Trachyte (Tertiary)	Pyrolusite	Quartz	...	
Sassari...	Ittiri	Kidney-shaped pieces of ore	Trachytic tufa (Tertiary)	Crystalline pyrolusite	Chalcedony and jasper	95·00	
,,	Osilo	(?)	Trachytic rocks ..	Lamellar pyrolusite...	Chalcedony	61·13	
,,	Padria ...	Small veins	Trachyte and limestone	Fibrous pyrolusite ...	... ...	...	At the plane of contact between the two rocks (trachyte below)‡
,,	Pozzo-Maggiore	In fissures (?) ...	Scoriaceous trachyte	Crystalline pyrolusite	... ...	73·00	
Prussian-Rhine	Königswinter	Small veins, 1in. thick	Trachytic conglomerate or tufa	Psilomelane	Iron ochre, ehrenbergite	...	The veins strike 9-11 hours, and dip 75° S.W. The "Country" is stained greenish yellow for 2" or 3" in the walls—surface-works, 1850.

* This is the mean of the samples taken by the writer *(see Analysis 2)*, and is the same as that given in the Government Returns. Ore of this percentage selling at Marseilles at 60 lires per ton, i.e., 1s. per unit.—*(Notizie statistiche sulla industria mineraria in Italia, al* 1880-1881.)

† It produced in 1857-8 475 metrical quintals of ore, of the value of 3,916 lires, and was then abandoned. *(See* Sella, *op. cit.*, and Goüin, *Notice sur les Mines de l'Ile de Sardaigne*, Table C.)

‡ "In contact with the trachyte and the Tertiary limestone the mineral is less pure, harder, and more quartzose."—(L. Goüin, *op. cit.*, p. 136.)

ORIGIN OF THE DEPOSIT.

Manganese being scattered throughout the tufa, its presence as a crystalline peroxide in fissures in the trachyte is readily accounted for. These fissures were formed during or subsequent to the consolidation of the rock, and the filling has taken place most probably by filtration from the sides. Similar fissures, filled with psilomelane, occur in trachytic tufa near Königswinter. At the Siebengebirge the tufa occupies a large tract at the base of solid trachyte. The mica in these rocks is black magnesian, and throughout the rock is scattered magnetic oxide of iron in little octahedral grains, enclosing a strong proportion of manganese and perhaps titanium. (R. Zeiller, *op. cit.*, p. 74).

The origin of the bed is not so apparent. No doubt the trachytic tufa of the Sardinian Provinces of Cagliari and Sassari was derived directly, like the similar rock of the Siebengebirge, from volcanic eruptions, and is not a mere conglomerate formed by the wear and tear of an older rock. A careful examination with a lens abundantly proves this. All the minerals composing the harder rock above are there, but in a soft and apparently decomposed condition. The upper and lower rocks have no doubt solidified under different physical conditions, and a certain amount of kaolinisation has since taken place in the latter. M. Zeiller supposes that the still more kaolinised tufa of the Siebengebirge was once in the condition of wet mud, but it would appear that in the case of the Sardinian tuff the volcanic area was at the time of its deposition covered to a large extent by the waters of a sea or inland lake.

La Marmora studied the trachytic rocks of the island with very great care, and his conclusions as to their mode of origin are as follows :—

"The emission of whitish pulverulent and incoherent matter has preluded the appearance of the trachytic rocks which cover them in the form of sheets (*coulées*), but angular fragments of these, as well as of retinite in the tufa, prove that when the latter was formed it was probably re-spread (*remanié*) and piled up (*tassé*) in a liquid such as sea-water, but before it had attained a certain consistence trachyte and retinite injections had already taken place. The products of these first eruptions of lava were soon dislocated, fractured, and re-arranged by a cause unknown to us, but which is very probably the same as that which has pulverized the ashy substance of the tufa . . . . . so that a certain time necessarily elapsed before the brecciform tufa was able to settle down (*se tasser*), consolidate into parallel beds, and be in a condition to support the weight of trachytic matter which was poured out (*épanchée*) over it in the form of a sheet."

But whence came the manganese ? The fact of its occurrence throughout the tufa in tiny patches, and its probable presence, too, in minute proportions in the magnetite with which the rock is scattered, incline one to think that manganese was somewhat largely present in the lava* as it flowed, or perhaps it would be nearer the truth to say, in the ashes as they dropped into the water. The temperature of the latter would, under such circumstances, be gradually raised until it was more or less saturated with bi-carbonate of manganese, together, of course, with some iron. The carbonates would gradually be oxidized by the free oxygen in the water, or they would lose their carbon dioxide by heat, and dioxide of manganese and peroxide of iron would be deposited in films. The cooling having reached a certain stage, and only a small proportion of manganese and iron remaining in the water, gelatinous silica, holding variable proportions of iron, might next be deposited, film upon film; the latter, by hardening and consolidation, eventually forming the jasper roof, so conspicuous for its beautiful colouring and so useful in exploitation.

The manganese bed is seen to be of a banded structure, minute films of peroxide of iron and pyrolusite alternating with films of yellowish ferruginous clay (the result of simple mechanical deposition), and, indeed, the tufa itself here and there shows the same structure ; so, whether the above explanation be true or false, these facts are a sure proof that all have been produced in a similar way, and are contemporaneous.

MODE OF EXPLOITATION.

The bed of manganese, as well as the superposed ochre, is worked out mainly by two galleries, no shaft having yet been sunk, the "Galerie Marie," 38 yards, and the "Galerie Camille," 10 yards above sea-level. By means of the first the higher portion of the deposit has been worked away. The second was begun in 1877, and, being only 30 feet above sea-level, by its means the portions of the seam below the level of the other gallery are being exploited. (See Section, Plate XXII.) It also forms the

* Lavas, as a rule, contain but traces of manganese or none at all, but analyses show several exceptions. Sanidine-trachyte from Isenburg contains from 0 to ·62 % of MnO. A "pitchstone" from Sardinia gave ·55 of the same. A specimen of sanidine-oligoclase-trachyte (Drachenfels) yielded 1·15 % of Mn_3O_4, and another 1·26 Mn_2O_3. Some phonolites show from ·5 to 1·45 % of MnO. A basalt from the Cape de Verde Islands had 3 %, and the same kind of rock from Java, 1·84 % of MnO. Lavas from Auvergne yield from 0 to 2 or 3 % of MnO, while one gave on analysis as much as 4·11 % (See Roth, *Die Gesteins-Analysen*, 1861, and *Beiträge zur Petrographie der plutonischen Gesteine*, 1869-1873.) Although manganese only occurs exceptionally in any proportion in lavas, as a matter of fact manganese *deposits* are not common in volcanic rocks.

drainage-level and main mineral-way of the mine. The section of the gallery is 7 by 6½ feet within the timbers. It has an arched roof, and cost 45 francs per current metre, or about 10s. 6d. per running foot. It is securely timbered by leg and cap pieces, except near the entrance, where the rock is sufficiently hard to stand by itself.

A cross-cut is first driven out from the gallery in the direction of strike; a rise is then put up from this cross level through the bed; small levels, 4 to 4½ feet high, and kept open by good timber at the sides and top, are next driven along the strike, and more or less parallel with the cross-cuts below. From these transverse galleries any number of working places (*chantiers*) are driven towards the rise of the bed. (See Nos. 1 to 7 on the Plan.) Two miners work in each *chantier*. The ground is worked in slices. The men first hole into the soft clay floor with a somewhat curved pick, having a hammer-head prolonged some inches beyond the handle. The clay which they constantly throw behind them forms the *remblais*, with which the old workings are filled up. A single prop only is necessary here and there, for after a time the pressure from above causes the floor to swell and to fill up any vacant spaces, at the same time rendering the filling more compact. The manganese is afterwards brought down by sledge-hammer and long and thick wedges; the ore is then wheeled in barrows to the shoot (*cheminée*) in connection with the cross-cut leading to the main gallery below. The shoots are about 2 by 3 feet section, and are placed at from 3 to 6 feet apart. The mineral is wheeled along the main gallery in strong iron wagons to ore-receptacles on the beach. Here it undergoes hand-picking, as it is necessarily mixed with some clay on account of its friability. Ore of three qualities is obtained:—(1) best, containing 38 per cent. of pyrolusite and upwards; (2) seconds, about 30 per cent. and upwards; and (3) thirds, under 30 per cent.

The large proportion of water (20 per cent. and upwards) in the ore as sent to market shows that some means of drying it should be adopted at the mine. A good round sum has been spent in attempts to form the ore into solid bricks, but as yet no satisfactory result has been obtained.

In 1882, the proportion of first-class ore was 90 per cent.; in 1883, best 10 per cent., seconds 66 per cent., thirds 24 per cent., but in the latter year picking was little attended to as a large contract was entered into for the delivery of second grade ore.

It will be seen that the mine is a cheap one to work, otherwise it would be useless to exploit with any shadow of success a bed of 10 inches, containing only on an average 30 per cent. of manganese.

The upper gallery is connected with the ore-receptacles on the beach by means of rails and an inclined plane; the two galleries are connected below by the inclined plane shown in Plate XXIII.

The actual cost per ton of ore loaded into vessels at Carlo Forte under the above method is as follows:—

	s.	d.
Getting (*abattage*)	4	9
Mending road		2½
Dressing	1	7
General expenses, including management, directorship, tax to Government, &c.	3	11½
Dead-work	2	4½
Freight to Carlo Forte	2	2
Loading in barks and unloading to stores...	1	2½
Total	16	2½

HISTORY.

The deposit as it crops out here and there along nearly the whole line of strike must long ago have attracted attention. According to Baldracco, the "ferriferous rocks" of the western end of the island were referred to by Belly in 1761. At the end of the eighteenth century some excavations were made; yellow ochre was found to be somewhat abundant, red ochre scarce, while the oxide of manganese was extracted and sold at Palermo for from 15 to 18 francs per quintal (*cantara*). Le Comte de Vargas evidently refers to these operations when he says, "On a découvert à Saint-Pierre une mine de manganèse." (*Journ. de Physique*, 1808, p. 59.)

For about forty years after this the mine remained idle. When La Marmora visited the island in 1834, he noticed some shallow excavations in the yellow ochre, but nothing was then actually being wrought. That the bed of pyrolusite had, during this period, fallen into utter obscurity is evident from the fact that, although Barelli describes specimens of jasper, trachyte, and even ochre and a few other minerals obtained from this island, he makes no mention of manganese (*op. cit.*, 1835). In 1847, its re-discovery was announced in the *Piedmontese Gazette*, and for ten years up to the time Baldracco wrote (1859), the yellow ochre and manganese were wrought by the peasants on a small scale. Goüin gives no figures from 1851 to 1865 in his Table C, but merely notes, "*quelques exploitations peu importantes.*" Indeed, up to 1871, the extractions were intermittent and insignificant, and the mineral not being found sufficiently

rich in oxygen for chemical purposes, was used only in the manufacture of iron. (*Relazionè del Deputato Sella, sulle condizionè dell' industria nell' isola di Sardegna*, 1871.)

In 1871, the Italian Government granted the "permissions of research," Capo Becco and Capo Rosso, to two French proprietors who worked the deposit vigorously for some years. According to Sella, the two concessions are of the date 1876.

STATISTICS.

The following table shows the production from 1854 to 1883. The figures from 1860 to 1881 inclusive, are taken from the Government returns, those for the campaign 1882–83 are from the books on the mine:—

Year.	Concession.	Number of Tons. (1 Ton = 2240 Lbs.)	Value per Ton in Shillings.	Total Value in Pounds Sterling.
1854	Capo Rosso	2·89	49·6	7
1860	„ „	48.98	48·9	120
1871–2	Capo Rosso ... Capo Becco ...	209	45·0	470
1872–3	Both concessions ...	445	45·0	1,001
1873–4	„ „ ...	979	44·0	2,154
1874–5	„ „ ...	712	55·7	1,983
1875–6	„ „ ...	766	53·8	2,060
1876–7	One concession ...	1,780	36·0	3,204
1877–8	Both concessions ...	2,670	31·5	4,205
1878–9	„ „ ...	3,738	27·0	5,046
1879–80	„ „ ...	3,738	27·0	5,046
1880–1	„ „ ...	4,895	27·0	6,608
1881–2	„ „ ...	8,900 ?	20·0 ?	8,900
1882–3	„ „ ...	10,235	20·0 ?	10,235

In round numbers, 39,000 tons of manganese has been raised, realizing £51,000, at an average value of about £1 6s. per ton.

In 1879, the return of manganese for the whole of Italy was only 5,077 tons, and in 1880, 5,705 tons, or, in other words, in the former year, the two concessions of Capo Rosso and Capo Becco produced nearly four-fifths of the whole return of manganese for that year, and in 1880, the proportion had risen to five-sixths. But, although the amount of manganese exploited in the rest of the kingdom had decreased by about 445 tons, the value of the ore sold from these smaller mines had risen from 29s. to 41s. per ton.

The steady decrease in value of the Capo Rosso ore from 1874, when it had reached the maximum of £2 8s. 6d. per ton, to 1878, when it was sold for less than half that amount, is not entirely due to a falling market, for the richest portion of the bed was worked first, and latterly, ore of an inferior grade has been contracted for (30 % of dioxide).

The present value of the second grade ore f.o.b. at Carlo Forte, may be taken at about 7d. per unit of metal, or at 1s. per unit delivered at an English port.

In 1878, 178 workmen were employed, but the average number from 1875–9 was 126 per annum. The mine is idle from the 1st of August to the 1st of November in each year, owing to the prevalence of *intemperie* (a kind of malaria) at that time of the year. The miners are chiefly from Tuscany; they are good workmen, although not particularly steady. They are paid from 3¼d. to 9¾d., or on an average 6½d. to 7½d. per ton of ore brought out on to the beach. The pickers are usually Sardes, and receive from 10d. to 1s. 8d. per day. They are harmless and steady, but as workmen are not to be compared with the Tuscan miners, although they improve by experience.

The yellow ochre, which, with the rarer red ochre, is wrought by rises put up from the floor, sells at from 45 to 50 francs, or say about £2 per ton, delivered to the port. The ore at Capo Rosso is loaded into boats of from 7 to 10 tons burden; it is then taken round the island to Carlo Forte, where it is stored up for drying. When dry it is loaded into vessels of 200 tons burden and shipped to English or foreign ports.

The concessions were obtained from the Italian Government on liberal terms; the Company have to pay annually £80 income tax and £48 royalty, or about £120 in all.

FUTURE EXPLOITATION.

The dip of the bed being towards land it is evident that the limit of exploitation by the present "Galerie Camille" will soon be reached. This limit varies from point to point on account of the folding of the bed along the line of strike. Taking the latter into account, and allowing about 830 lbs. for each square yard of the bed, the amount of ore that can be taken away down to the floor of the present gallery is from 18,000 to 20,000 tons. But owing to the narrowness of the workings and the absence of shafts, with the exception of one or two air-holes, it is highly questionable whether this quantity can be worked out in anything like a reasonable time without sinking a large shaft to the dip and connecting

it with the lower gallery. The air above the gallery, as may be readily understood, is exceedingly sluggish, and the temperature abnormally high. Although the mine is above sea-level the men work bare to the waist even in winter.

At the writer's request, M. Lacroix, the surveyor at the mine, tested the temperature with a thermometer.

1. At the mouth of the "*Galerie Camille*" it was 14°·5 C., or 58°·1 F.
2. At *Fourneau*, No. 2 ... ... „ 18°·5 C., or 65°·3 F.
3. At *Chantier*, No. 2 ... ... „ 24°·0 C., or 75°·2 F.

i.e., a rise of 17° F., and in another *chantier* the temperature appeared to be several degrees higher than this.

An enlargement of the workings in the bed itself by taking up more of the floor seems desirable, the men would then have more room in which to work, and the ventilation would be improved.

A double line of rails could be laid in the lower gallery for an increased output, and the carriage of the ore from the bed to the sea should be made as self-acting as possible.

The necessity of some means of drying and condensing the ore has already been pointed out. Although the item of general expenses, picking and freightage might possibly be reduced 3s., or even 4s. per ton, it must be remembered that as soon as the bed is worked below the lower gallery the cost of raising the ore, the wear and tear of machinery, and the interest on capital invested would no doubt exceed the above amount per ton.

An examination of the figures given will show that the margin for profit, at the present price of the ore, is small, too small to allow one to attach much commercial importance to the deposit as it stands; but the mine has been of value in the past, for it has undoubtedly for a whole decade sent a large quantity of manganese ore to the market.

The following "Notes on Microscopic Sections of Rocks from San Pietro, Sardinia," by Mr. F. W. Rudler, F.G.S., being an appendix to Mr. Halse's paper, were read :—

To illustrate Mr E. Halse's paper "On t

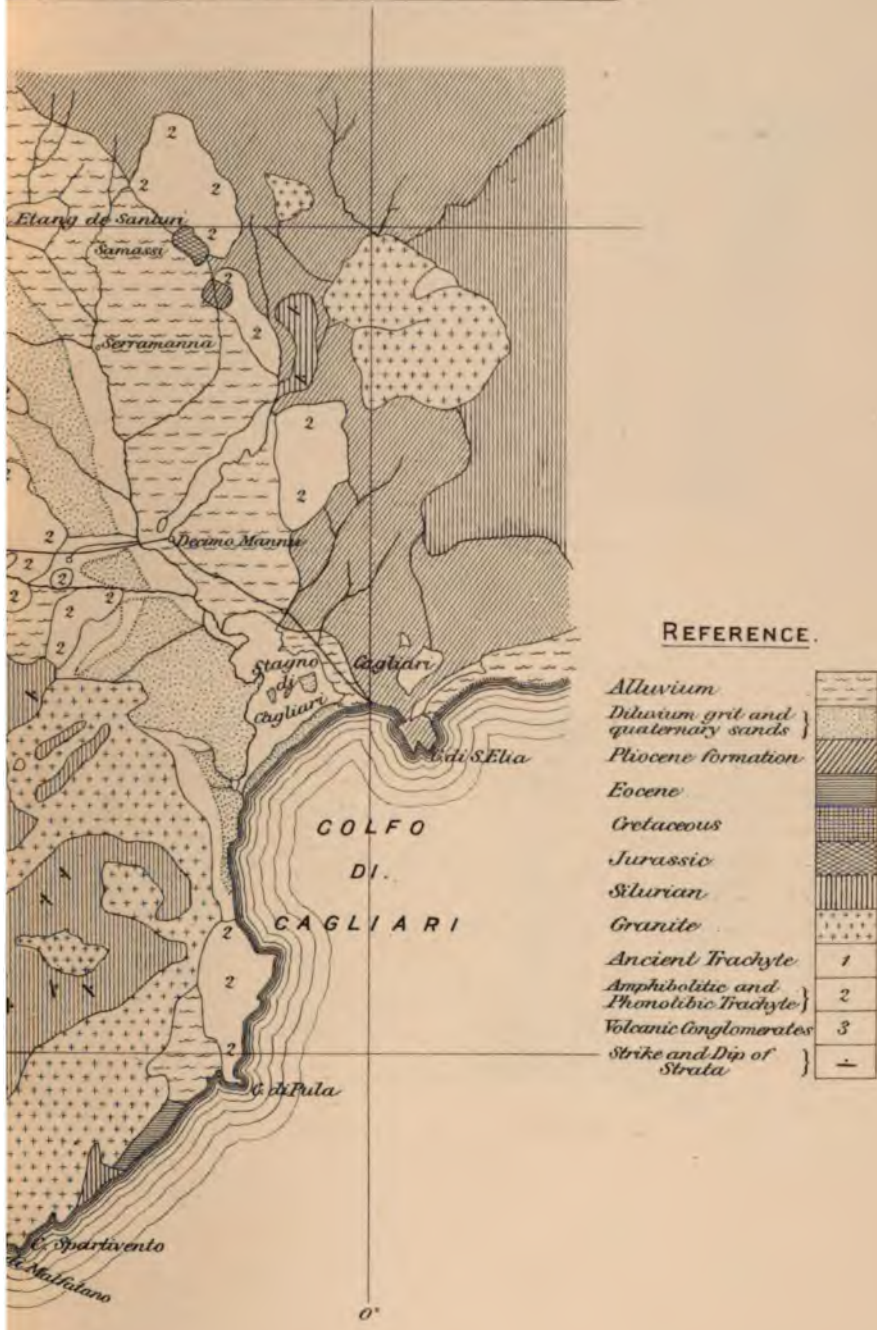
MAP SHEWING THE VOLCANIC ROCKS OF T

Proceedings Nº LI of Ms. M.E. 30th '98

Geogra

nganese Deposit of the Islet of San Pietro."

UTH WEST OF SARDINIA. (After La Marmora.)

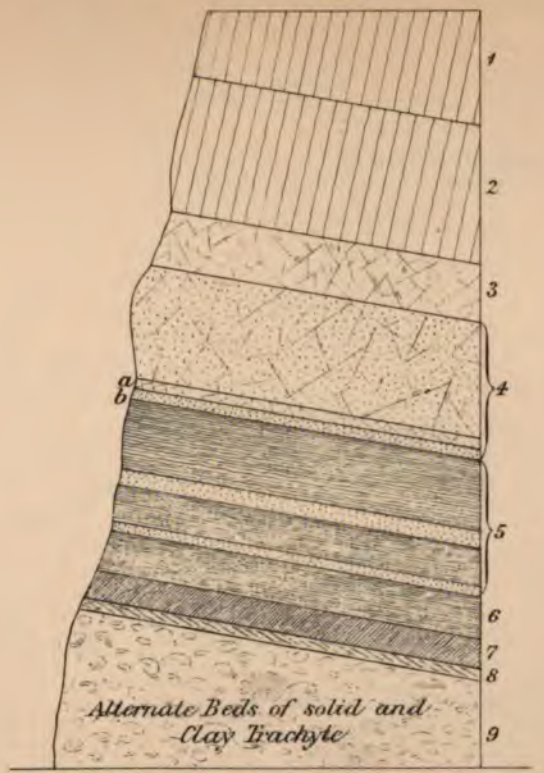


REFERENCE.

- Alluvium
- Diluvium grit and quaternary sands
- Pliocene formation
- Eocene
- Cretaceous
- Jurassic
- Silurian
- Granite
- Ancient Trachyte — 1
- Amphibolitic and Phonolitic Trachyte — 2
- Volcanic Conglomerates — 3
- Strike and Dip of Strata — 2

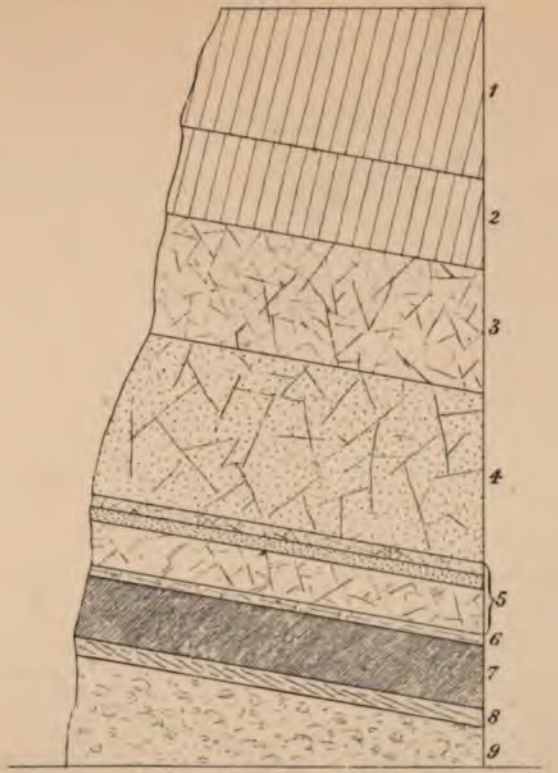
To illustrate M.r E. Halse's paper "On the Manganese Deposit of the Islet of San Pietro."

FIG. 1.



SECTION OF TRACHYTE ROCKS ABOVE THE "GALERIE CAMILLE."

FIG. 2.

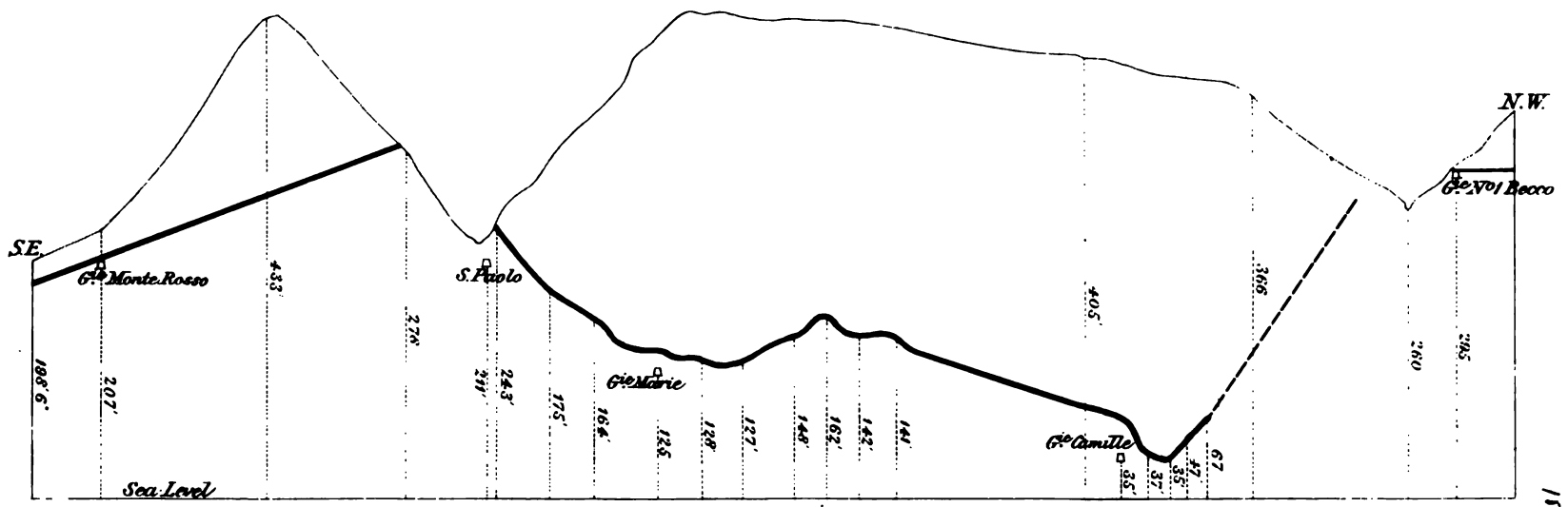


SECTION OF TRACHYTE ROCKS AT "RIPA DELLA TINTA"

Proceedings N.° E.I of M.& M.E. 1884-85

To illustrate Mr E. Halse's paper "On the Manganese Deposit of the Islet of San Pietro."

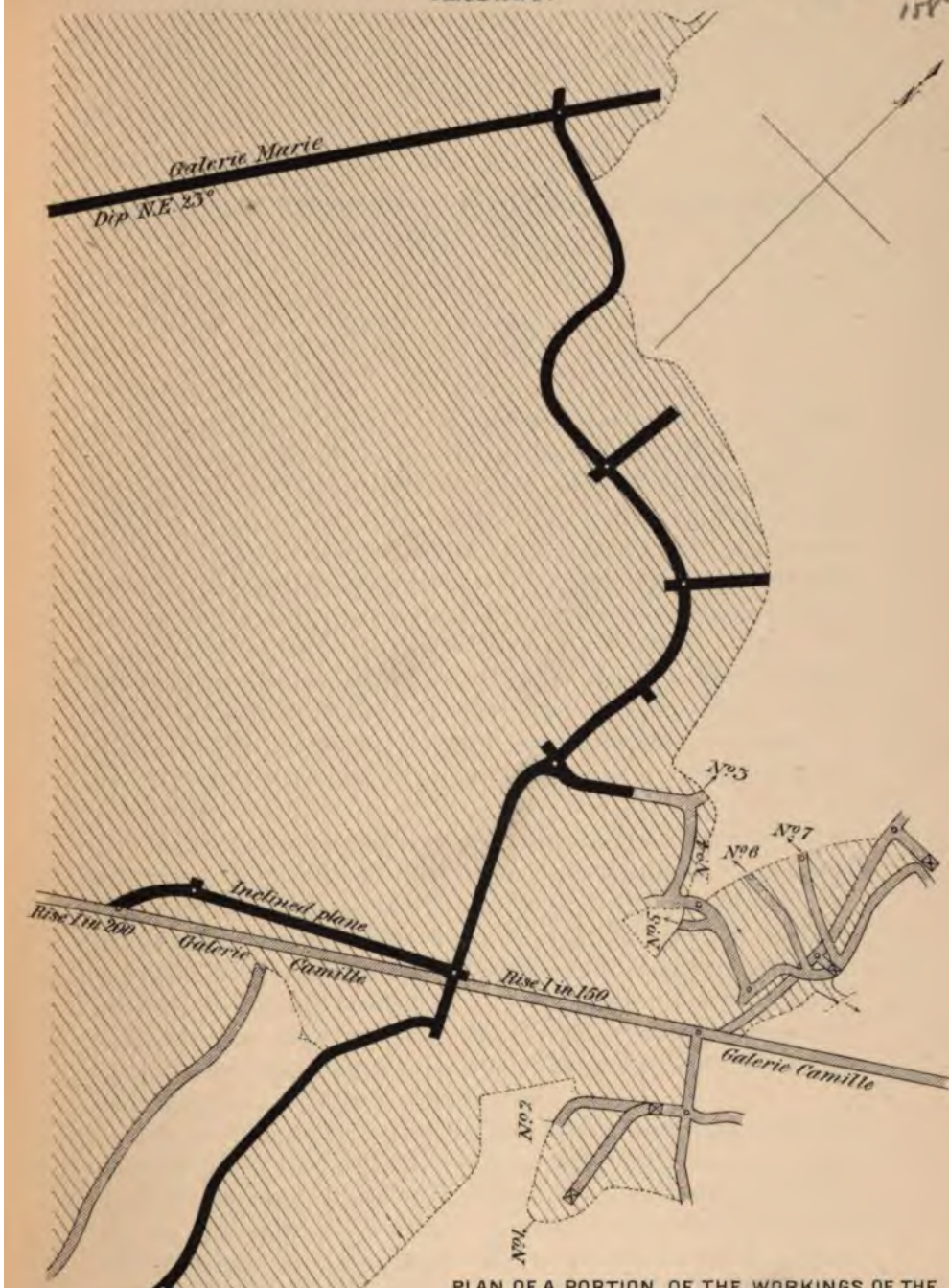
LONGITUDINAL SECTION.



Proceedings N.° ET of M. & M. E. 1894-95

172

To illustrate Mr E. Halse's paper "On the Manganese Deposit of the Islet of San Pietro."



PLAN OF A PORTION OF THE WORKINGS OF THE CAPO ROSSO MINE, SAN PIETRO, TO JANUARY 27TH 1884.

REFERENCE.

Workings on the "Galerie Camille"
do do "Galerie Marie"
Portion of Bed already exploited
The small figures=height in feet above Sea Level.

Scale 2000

NOTES ON MICROSCOPIC SECTIONS OF ROCKS FROM SAN PIETRO, SARDINIA.

By F. W. RUDLER, F.G.S.

No. 1.—This is a section of a trachytic rock, with a brownish ground-mass, coloured with peroxide of iron, and displaying very distinct fluxion-structure. In this ground-mass there are embedded crystals of sanidine, plagioclase, and biotite. The sanidine occurs in clear prismatic crystals, showing the usual transverse fissures; and in some cases it may be seen that the two portions of a crystal have become dislocated, so as to present the appearance of microscopic faulting. The biotite, or brown magnesian mica, exhibits the characteristic dichroism of this species. Most of the sections have been cut across the cleavage planes, so as to expose the edges of the laminæ, and they also show the usual ragged or fringed ends of biotite crystals. Magnetite is present, and the section is traversed by a narrow black vein, which may perhaps be a string of black oxide of manganese.

No. 2.—This is a trachytic rock, presenting suggestive resemblance to a rhyolite. Its ground-mass, rich in glassy matter, displays to perfection that kind of fluid-structure which Professor Rutley has appropriately designated the *damascened* structure. Through this base are sprinkled crystals of felspar and mica. The felspar seems to be chiefly plagioclastic, with the well-known banding of its polysynthetic twin-crystals. The crystals enclose blebby masses of glassy matter, which may represent an original matrix since partly devitrified. The mica is biotite, in characteristic forms. Magnetite is also present.

No. 3.—This section is much less transparent than the preceding, and must have been cut from a rock which has suffered alteration. It shows a dark brown cloudy ground-mass, highly charged with peroxide of iron, and in some parts almost opaque. Crystals of plagioclase containing various endomorphs, are porphyritically embedded in the matrix. These crystals carry numerous glass enclosures, which are probably portions of a vitreous base entangled in the felspar during its crystallization. A little

biotite is sprinkled through the section. As the blowpipe reveals the presence of manganese, it is possible that certain opaque patches in the rock may be due to the black oxide of that metal.

No. 4.—This section of tuff displays an aphanitic ground-mass, with well-defined crystals of biotite, having curved laminæ sprinkled through the mass. The felspar seems to have been for the most part decomposed, and removed from the section, leaving only hollows indicating its former presence. A black material occurring in patches is probably in part magnetite, but perhaps also in part oxide of manganese.

No. 5.—This rock has suffered much decomposition, and little can be said about its microscopic character. It presents an almost opaque ground-mass, containing altered crystals of felspar. The products of alteration seem to be in part zeolitic.

No. 6.—This rock is similar to the last, but the granular ground-mass is much lighter in colour. There are flakes of biotite and crystals of felspar present; but the latter have suffered much decomposition, and are partly represented by secondary products.

The most interesting points connected with these San Pietro rocks, from a petrological point of view, are the vitreous character of some of the ground-mass, the beautiful fluxion-structure which it presents, and the absence of quartz in all the specimens.

During the reading of Mr. Rudler's notes, Professors Lebour and Bedson, by means of a lantern, showed specimens of the rock.

Mr. W. G. LAWS proposed a vote of thanks to Mr. Halse for his paper, and to Professor Lebour for communicating it; also to Professor Bedson for the illustrations by the lantern.

Mr. ROBINSON seconded the motion, and it was agreed to.

PROFESSOR LEBOUR said, he believed every one of the specimens of rock mentioned in the paper were represented by small specimens upon the table, and numbered in the same way as the sections in the paper. Mr. Rudler's petrological descriptions (given as an Appendix to the paper) were extremely technical, and except to a petrologist were almost unreadable. If any one liked to look at the sections they could do so in his (Mr. Lebour's) room by means of the instrument.

The following paper on "The Marsaut Lamp," by Mr. M. Walton Brown, was read:—

ON THE MARSAUT LAMP.

By M. WALTON BROWN.

THIS safety mining lamp, the recent invention of Mr. J. B. Marsaut,* the chief engineer to the Bessèges Coal Company, exhibits in general form and construction the Mueseler type.

Its construction is detailed in Plate XXIV., showing the following parts:—

(*a*) Oil reservoir and wick holder.
(*b*) Glass.
(*c*) Frame for containing the glass.
(*d*) Inner gauze.
(*e*) Outer gauze attached to a copper flange.
(*f*) Protecting shield.

There is nothing special in the lamp bottom with the exception of the high position and use of a flat wick; this has been adopted so as to increase the size of the wick and the lighting power of the lamp.

The glass used is of considerable thickness and carefully ground at both ends to secure an efficient joint when the bottom is screwed on. The internal diameter of the glass is the same as that of the lower portion of the inner gauze.

The inner gauze affords a large surface for the cooling and escape of the burnt gases.

The outer gauze is attached to a copper flange which holds the top of the glass.

The protecting shield is removable and is made independent, or not, of the lamp when locked. It is furnished at the bottom with openings for the feed air, placed as low as possible, so as to be opposite the ring at the bottom of the gauze and prevent the direct entry of horizontal currents of air into the lamp.

* In Vol. LXXII., page 248, of the Proceedings of the Institution of Civil Engineers, there is an abstract of a paper written by Mr. J. B. Marsaut himself on this subject.

Openings for the exit of the smoke are provided at the top of the shield, which may be covered by a ring to destroy the action of currents of air on the top of the lamp.

The manufacturers in Great Britain are Messrs. J. Mills and Sons, of Newcastle-upon-Tyne, who add a simple, cheap, and effective arrangement for simultaneously locking the oil reservoir, frame, and protecting shield. This lock, the invention of Mr. W. J. A. Ryder, may be described as follows:—The protecting shield is attached to a brass rim which screws on to the frame of the lamp, to which the oil reservoir is similarly attached. One of the pillars of the frame of the lamp is movable, and by placing it into sockets pierced in the rim of the shield and in the oil reservoir, and fastening the pillar with a lead plug, or padlock, the whole of the parts of the lamp are securely locked together. The same arrangement of the movable pillar can be used for locking the shield only, and allowing the pillar to rest on the oil reservoir, so that it cannot be withdrawn from the socket in the rim of the shield; in this case the oil reservoir will be locked to the frame by any of the usual methods.

In the construction of the lamp Mr. Marsaut has carefully taken the following influences into consideration:—

The internal volume of the lamp, and the ratio between the volume and the surface of gauze.

Influence of the burnt gases.

Mode of admission of the air supply.

From experiments made by placing lamps into a bell in order to receive the gas, and then lowering them to its edge, it was found that lamps of large internal volume were dangerous, in consequence of the violence of the internal explosions and of the relative frequency of the external ignitions. Experiments of this nature appear to re-produce more or less what must frequently be done with either a full or reduced flame in fiery mines, in order to ascertain the presence of gas.

Again, when the gauze of a lamp was partially obstructed by a band of paper placed around it, it was found that the external explosions were much more frequent when the surface for the escape of the gases was diminished.

In two types of the Mueseler lamp, only differing in internal volume, out of about 2,200 experiments with each lamp, the one of larger volume fired 86 times, whereas the one of smaller volume only fired 56 times.

Many interesting experiments may be made to show the influence of the burnt gases. Thus, with a Mueseler chimney without the diaphragm added to a Clanny lamp, in a series of 97 trials there were seven external explosions, whilst in 760 trials the ordinary Clanny only fired once.

Again, with the addition of a Rosenkrantz chimney to a Boty lamp, there were three external explosions in 184 trials, whilst the simple Boty lamp did not fire once in 2,094 trials.

It appears, therefore, that the isolation by any means of the burnt gases is an element of danger, and that the part performed by these gases (the dilution of the explosive mixture in its approach to the flame) constitutes an element of safety in the Clanny and Boty lamps.

The mode of admission of the air supply must also be considered. By tests in the bell it is seen that the flame of the explosion rarely extends below the level of the flame of the lamp, when the air is admitted from above. In the case of a high wick, the phenomena is very apparent: there appears to be a cushion of air at the bottom of the glass, which reduces the explosive volume, and whose elasticity must reduce the intensity of the explosion. From experiments upon the Boty lamp, in which the air descends from above, and the Westphalian lamp, with air admitted below the glass, with lamps of the same shape, volume, and gauze, it was found that whilst the Boty lamp did not cause one external explosion in 2,094 trials, the Westphalian lamp failed thrice out of 640 trials. The glass in these lamps must be as detrimental as the band of paper partially obstructing the gauze, and the failure of the Westphalian lamp can only be attributed to the altered position of the glass (or the band of paper), in fact, to the admission of the air below the glass.

This is proved by experiments upon a Gard-Davy lamp, with a gauze $2\frac{5}{8}$ inches diameter. This lamp was arranged by means of bands of paper, to simulate an arrangement like the Boty lamp, admitting the air from above; and, like the Westphalian lamp, so placed that the air was admitted partly from above and partly from below the paper by an open ring.

The trial of these two arrangements afforded a fair test of the modes of admitting the air supply. In 144 trials with the Boty arrangement, the internal explosions were much less violent, and afforded only one external explosion; whilst the Westphalian arrangement gave three external explosions in 55 trials.

If the wick-holder is raised in a lamp supplied with air from above, it will have the same effect as reducing the height of the glass, and at the same time it must increase the neutral space at the bottom of the lamp; and from Messrs. Mallard and Le Chatelier's experiments on explosive mixtures in tubes, it seems probable that this modification will have its advantages, and prevent in addition the consequences which might result from closing the bottom of the lamp.

Repeated trials have shown the insufficiency of a single gauze. Thus, a Gard-Davy lamp, with gauze of 2⅝-inch diameter, gave repeated failures, but the addition of an inner gauze separated a little from the outer one, rarely allowed the passage of the flame to the outside. Two similar gauzes in the Boty lamp have always resisted the flame, even with the addition of the Mueseler chimney without the diaphragm.

The latter result is of importance, as it practically confirms what has already been said upon the influence of the burnt gases, and the mode of admission of the air.

The danger of the varying velocities and direction of explosive currents upon safety lamps has been frequently shown in various experiments. The remedy can be readily applied to most of the lamps in use by the addition of a suitable shield. The adoption of a shield is by no means a new idea. The Stephenson lamp is a practical instance of its useful application, and Davy pointed out its advantages at a very early period after the introduction of lamps.

The most primitive is the external shield attached to the frame of a Davy lamp, whose use is mainly to preserve the light. Another variety is the addition of a ring of glass, which (whilst being efficacious against currents) is certainly dangerous, for it reproduces the arrangement of a band of paper, the danger of which has been described.

The use of a high internal shield, as in the case of the Stephenson lamp, must be dangerous in the event of internal explosion, although it enables the lamp to resist the effects of explosive currents at high velocities even better than the Mueseler; it will act in the same manner as the band of paper, and prove the cause of failure when tried in the bell.

It is therefore evident that the shield (in order to be most useful) must be placed outside and at some distance from the gauze.

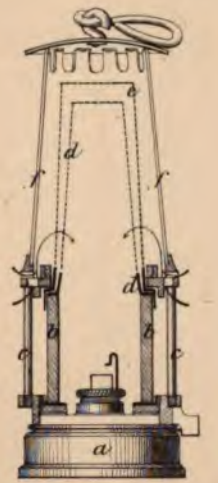
The advantages claimed by Mr. Marsaut for his lamp, and which have now been verified by numerous experiments, are :—

1. It does not go out so readily, when inclined, as the Mueseler lamp, and cannot be inclined for such a length of time so that the flame may crack or smoke the glass;
2. It is not extinguished in vertical ascending or descending currents of air;
3. It does not cause external explosion when exposed to rapid explosive currents under ordinary conditions;
4. It does not cause external explosion when introduced into still explosive mixtures;
5. The gauzes are protected from external injury by dust or water;

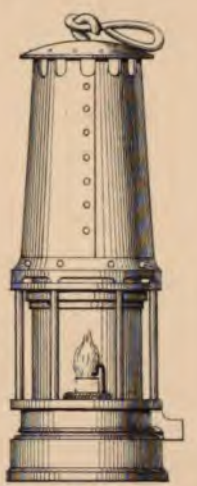
To illustrate Mr. M. Walton Brown's paper "On the Marsaut Lamp"

Half Size.

Quarter Size.



No 1



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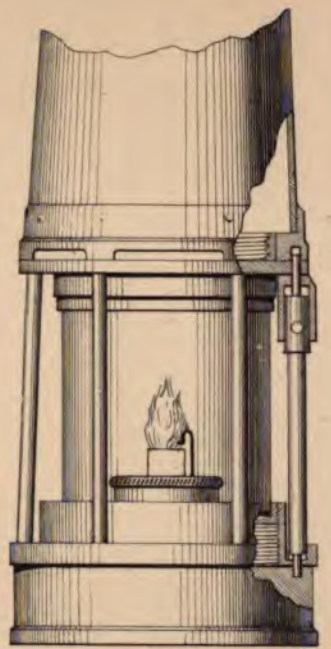

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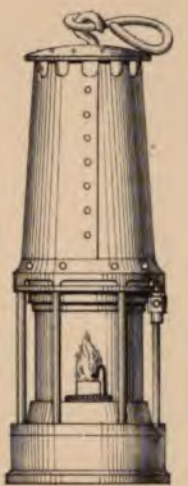
Quarter Size.



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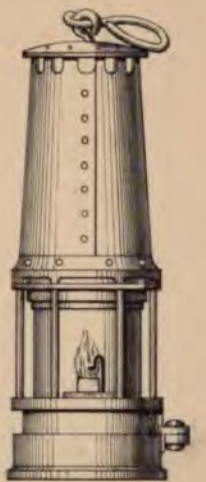


No 5.

WITH RYDER'S IMPROVED MODE OF FASTENING THE LAMP.

Proceedings N° E.I of M.& M.E. 1884-85.

6. The burnt gases resulting from internal explosion are momentarily retained within the shield, and aid in the extinction of the lamp by mixing with the air supply;
7. The lamp can be readily extinguished when required by obstructing the supply and smoke openings by means of the hand or jacket.

The writer is indebted to the courtesy of Mr. Marsaut for the details of his experiments upon safety mining lamps, which were communicated to the Société de l'Industrie Minérale, and are contained in Volume XII. of their Bulletin.

The PRESIDENT said, they had heard a very interesting paper on a subject of importance, and he would be glad to hear any remarks upon it.

Mr. STEAVENSON said, he thought the Marsaut lamp an exceedingly good lamp. He had used it once or twice in the pit and it gave a good light. He did not see in what way it differed from the Mueseler lamp. Of course the question arose whether such heavy lamps were necessary. They could be used very well for hewers, but when officials got hold of them they were rather heavy to carry about in the small passage ways. If they wanted a useful lamp and one which gave a good light for hewers, the Marsaut seemed to him an exceedingly good one.

Mr. ROUTLEDGE said he would like to know where the Marsaut lamp gave increased security over the old Clanny lamp which had been in use for years and was in use to-day. He believed that the weakest place in the Clanny lamp was the glass.

The PRESIDENT said, the difficulty they encountered in using new lamps was, that the safer they were, the more difficult it became to work with them. He had used the Marsaut lamp, but without practical success. The workmen did not like it. The light in the Marsaut lamp went out very easily in a current. He had tried two of these lamps, and he could not get the workmen to take to them; but he did not know that great stress could be laid on this, because he had the same experience when introducing the Mueseler lamp. In many pits, especially in South Wales, the workmen would not use the Mueseler at all. In other places, in the county of Durham for instance, there was no difficulty in introducing the Mueseler lamp, and after using it for some time the men seemed to like it as well as the Clanny or any other lamp. Certainly the workmen in Wales had to set their timber, and a lamp was subject there to being turned more on one side, and the light went out more easily.

Mr. STEAVENSON said, he was glad to see Mr. Willis present. Mr. Willis had had a large experience in regard to lamps, and they would be glad to know whether he had ever met with an explosive atmosphere where the current was from 5 or 10 feet a second. In the case of a blower they need not go near it, and if they did so with a Geordy lamp it would go out. If a lamp could be made as light as the Davy lamp, and at the same time safer, they would be glad to have it. He thought the Mueseler lamp was as safe as any lamp he knew for the use of hewers.

Mr. WALTON BROWN thought Mr. Marsaut did not claim that his was a perfect lamp, but only that it was an improvement upon the Mueseler type of lamp. The Marsaut lamp did not contain the chimney and horizontal diaphragm of the Mueseler lamp. The Boty lamp was practically the same as the Clanny lamp, inasmuch as the air was admitted over the top of the glass. The Westphalian lamp was similar to the Clanny type of lamp, having no chimney or diaphragm, and the air came partly under the bottom of, and partly over the top of the glass. At several large collieries in the north where this lamp was partly used, the workmen said they liked it better than the Mueseler because it did not go out so readily when tilted.

The PRESIDENT observed that he did not say when tilted, but that a Marsaut lamp goes out more readily in a current than the Mueseler.

Mr. WALTON BROWN—Experiments show that the Marsaut lamp safely withstands currents of more than 40 feet per second.

Mr. J. D. WILSON said he had 60 Marsaut lamps in use for four months, and never heard of one going out in a current.

The PRESIDENT—Information of this kind can only be obtained from the practical experience of workmen; and there is this difficulty in getting correct information, that if a man does not like a lamp, he puts it out on purpose.

Mr. WILSON said, he thought that the Marsaut gave the best light and did not go out as readily as other lamps. Altogether he had had no complaint about it. When any new invention was brought forward the men urged various grievances about it, but in regard to the Marsaut lamp there had not been any at all; it had given every satisfaction.

Mr. WALTON BROWN said, the Marsaut lamp was safer than the Clanny lamp, inasmuch as it was less affected by rapid currents of air.

The PRESIDENT said, he took it that the Marsaut lamp was safer than the Clanny was, because if they took a Clanny into an explosive atmosphere they got the gauze gradually filled with inflammable gas

which might pass the flame. The Clanny passed the flame in the upper part, and not in the glass; and therefore it was the upper part that was the weak part of the Clanny, and not the glass. It might happen that a glass was broken, but this was of very rare occurrence.

Mr. WALTON BROWN—The Marsaut lamp has two, whereas the Clanny lamp has only one gauze. The shield of the Marsaut lamp protects the gauzes from the effects of rapid currents of air, which might, when the lamp fired internally, pass the flame and cause external ignition.

Mr. ROUTLEDGE said he had some experience of the Clanny lamp. There was, first, the temperature of the lamp itself, it being put together to a temperature of 50 degrees in the lamp cabin; and when they got to the face in the mine, there was perhaps 84 or 85 degrees of heat, and the additional heat of the lamp; and when they came back to the cooler atmosphere, they would find the glass of the lamp very slack, which has always caused it to be looked on with suspicion.

Mr. WALTON BROWN—In putting a lamp together the glass should not be locked up too tightly, as there would be a risk of breaking it. In any lamp with a glass there is trouble with the expansion of the parts, due to variations of temperature.

Mr. STEAVENSON had great pleasure in proposing a vote of thanks to Mr. Walton Brown for having brought the Marsaut lamp under their notice. They had long heard of it upon the Continent and in other parts of England, and it was right that this Institute should know all about it.

Mr. W. G. LAWS seconded the vote of thanks, and it was agreed to.

The PRESIDENT announced that Professor Lebour's paper "On the Breccia-Gashes of the Durham coast, and some recent Earth-Shakes at Sunderland," was open for discussion.

The SECRETARY said Mr. Richard Forster had sent a diagram showing the height of water at the back of the tubbing at Murton Colliery, during the year 1880 to the present time, but was unavoidably unable to be present himself, and wished, even if the discussion took place now, that it should not be finally closed until he was able to attend.

Professor LEBOUR said, if Mr. Forster had been present to explain the diagram, he (Professor Lebour) would have had something to say upon the subject; but, in Mr. Forster's absence, he would postpone his remarks until the adjourned discussion.

The discussion was adjourned.

Mr. M. Walton Brown's paper "On the Observation of Earth-Shakes or Tremors, in order to foretell the issue of sudden Outbursts of Fire-Damp," was then discussed.

The SECRETARY said Mr. Brown had in the room an instrument by means of which earth-shakes might be recorded.

Mr. BROWN said he had placed the machine ready for use before the beginning of the meeting, and the oscillation or tilting of the floor caused by people entering the room was orally shown by the ringing of the attached bell. If the machine were placed on the locality where the earth-shakes had been felt at Sunderland, he thought it would show that the earth-shakes were still going on. A month ago, some people living in the neighbourhood of Sunderland had again felt the shakes. He had sent a letter on the subject to Professor J. A. Ewing, who had been connected with the observation of earth-shakes in Japan, but who had recently returned home, and was now connected with the University at Dundee, and that gentleman had replied as follows :—

UNIVERSITY COLLEGE, DUNDEE,

November 8th, 1884.

DEAR SIR,—I am much interested in the information you give me about the recent and remarkably frequent earthquakes at Sunderland. I notice by the table of statistics of shocks felt from December to April last, that they were then occurring at the rate of nine or ten a month on the average. Can you tell me whether they have continued with anything like this frequency, and whether they are still as active. Can you also tell me anything as to the extent over which any one shock is felt; whether the places affected are immediately over or close to coal-workings; and what are the geological features of the district.

Even if these shocks are due to nothing else than falls in coal-pits, it is a matter of no small interest to obtain exact knowledge by instrumental observation of the character of the movements which the surface of the ground performs.

This, in fact, is a much more interesting and important part of the enquiry than the mere record of the times at which the shocks are felt. For the latter purpose a pendulum contact-breaker (such as you name), which either stops a clock or (better) registers the position of the hand at the time of the shock, will answer very well.

But it appears from the table you send that from December to April the frequency of these shocks was more than sufficient to warrant the construction and use of instruments which would give an exact analysis of the motion; and if the shocks have not yet notably diminished in frequency, I would strongly advise the immediate examination of them in this way.

This is a kind of work which I did in Japan for some years, with results which are described in the Memoir I send you along with this letter.

From the description given of these Sunderland shocks it is clear that the same type of instruments which I used in Japan would serve well to give records of these. Of these the most satisfactory and convenient is the Horizontal Pendulum Seismograph for horizontal movement, and the Vertical-motion Seismograph for vertical movements.

Both instruments can be set to give records on the same revolving smoked-glass plate. The expense of constructing and setting up of such a seismograph would be, I imagine, about £25.

Good results could be got from it only by the expenditure of much care and pains on the part of the observer who undertakes the charge of the instrument; but, indeed, without this no earthquake observations have any value.

If you see your way to instituting observations, I should be very glad to superintend the construction of suitable instruments, and to direct their use.

Perhaps you can obtain a grant from some local scientific society to cover the expense.

I shall be glad to hear further from you on this very interesting subject, and to receive any particulars of the Sunderland shocks you are good enough to send me.

Yours faithfully,

M. WALTON BROWN, ESQ. J. A. EWING.

Since writing this Mr. Ewing had received a grant of £100 from the British Association to observe the earth-shakes experienced on the top of Ben Nevis. It appeared they had been felt at that place, and it was intended to erect instruments and make observations there. He (Mr. Walton Brown) intended to place his instrument at Sunderland to see if the shakes continued there, and if they did not, then he would place the instrument above some ordinary broken workings, and endeavour to ascertain the nature of the effects experienced upon the surface.

The PRESIDENT—Is this a similar instrument to what has been used for keeping a record of earth-shakes in Japan, where they occur to a large extent?

Mr. BROWN—Yes. He could not say the exact number—60 or 70 earthquakes proper, and earth-shakes innumerable between, were experienced annually in Japan. The Japanese Government were conducting experiments at the Takashima collieries as to these earth-shakes, and found that there was an increase in the quantity of gas ten hours after the earth-shakes were observed, so that they had ten hours warning of the gas coming off. He might add that, in the Transactions of the Midland Institute, Vol. IX., page 371, there was a paper by Mr. C. E. Rhodes, which described an outburst of gas at one of the long-wall workings in Aldwark Main Colliery. In this case, about ten hours before the accident, women and children living in the workmen's cottages felt a violent shake, which even broke some of their crockery-ware. Ten hours after the shake immense volumes of gas came off in a district of the upper or Swallow Wood Seam. It seemed clear that the shock was not due to any heavy fall of roof in the mine, but rather was the result, more violently than usual, of an earth-shake similar

to those experienced at Sunderland. Whatever was the cause of the shock, it had evidently opened a series of fissures connected with some large reservoir, for the gas was still coming off in large quantities.

The SECRETARY asked to be allowed to make a few remarks upon this paper, which he thought was a most important one, because it might tend to alter the opinions of those who are continually pointing to the barometer as a sure means of telling when an explosion was likely to take place. He knew that this habit had been fostered by repeated Acts of Parliament, but he thought that this paper successfully proved that the safety of miners was not always increased by Acts of Parliament. Numberless attempts had been made to form rules, based on barometrical readings, to regulate the actions of miners, but nobody, he thought, could find any rule whereby the barometer afforded anything like a sign of the comparative danger a mine was running with reference to explosions, at any given time, as these explosions seemed to occur without warning, when the barometer was rising, falling, or steady, in the most capricious way. It seemed to him that Mr. Brown's paper was valuable inasmuch as it led them to think of the very much more numerous and grave sources of accident which lie hid in phenomena infinitely more difficult of observation than the pressure of the atmosphere. They must look to the vast and varied number of these phenomena that experience has shown to be constantly working changes in all bodies subject to variations of temperature and pressure, both from air, water, electricity, and numberless other agencies that were ever taking place in connection with the crust of the earth, and notably these earth-shakes. They all knew that the earth was permeated with fissures, some connected and some unconnected with one another, which connection could be broken or restored by a very slight motion of the earth's crust, in a way that had yet to be found out. Earth-shakes might open fissures and close fissures, and so cause the outbreak of gas in pits in a way easily understood but which it was utterly impossible for them to discover by any hitherto known practical means. The barometer, he believed, was now generally admitted to be of very little use in this matter; and it seemed to him that the sooner its readings were supplemented by some more extended researches into the secret doings of mother earth the better, and he thought it well that Mr. Brown had drawn their attention to at least one of these multitudinous phenomena of nature, any of which, or any combination of which, may have such influence on the safety of the pits, and it clearly became the duty of the Institute to facilitate all reasonable efforts to at least record these earth-shakes and endeavour to

obtain such rules from the observations thus made as might ultimately have the effect of fore-arming engineers against the evils they might produce. This was important in another point of view. They all knew that, despite the most constant care and attention, accidents from explosions would unfortunately happen, and that there were persons who were so ill-natured when these accidents occurred as to ascribe them to want of caution or attention. This paper would tend to show people not connected with mines, and who looked upon miners' lives as being, to some extent, neglected, that there were really a number of causes hitherto not dreamed of which affect the issue of gas, and which may cause sudden and wholly unexpected emissions which no practical man could really be supposed to be aware of. This would make people see and appreciate the difficulties miners have to encounter, and be more careful how they accuse the managers of collieries of want of caution.

Professor LEBOUR said, there seemed to be no doubt as to the very frequent recurrence of earthquakes, earth-shakes, or earth-tremors in Britain, as well as over the whole of western Europe. Some years ago, one of the late Mr. Darwin's sons conducted operations at Cambridge, which proved minute tremors there to be of the greatest degree of frequency; and it seemed strange to him (Professor Lebour) that so much time should have elapsed before the application of that knowledge to some observational means of fore-telling possible openings of fissures, and the possible consequent explosions from the opening of stores of gas. Oddly enough, within the last two years much attention had been drawn to the subject, and in almost every country in Europe observations were now being conducted. He thought England was the only exception, and was the only country in which no such observations were being made, though now Mr. Ewing had been appointed to conduct observations on Ben Nevis. He could not help repeating what he said when Mr. Brown read his paper, that it was within the province of this Institute, either by itself or with other Institutes, to carry out such observations by means of a grant, or by providing proper observers and suitable places. It was obvious that the instrument shown by Mr. Brown, though satisfactory so far as it went, was useless unless there were a certain number of them in certain places, a sufficient distance apart. If there was a net-work of these instruments and the observations were collated they would be very valuable. Observations at Sunderland would, no doubt, be of some interest, but they would be of insignificant value as compared with what a complete series of observations would be. He did not wish to make any motion on the subject, but he would like some

feeling on this question to be cultivated, which would end in, first, the nominating of a small committee to consider the advisability of starting observations of this kind, and then to report and suggest to the Institute, as a body, what might be done in this line. He thought this quite a proper subject for the Institute to take into consideration and that the results would probably be very valuable indeed. He would not make any formal motion but would throw out the suggestion which any one might take up.

The PRESIDENT said he took a great deal of interest in the remarks of Mr. Bunning and Professor Lebour, and he hoped Professor Lebour would bring the matter before the Council and see if a committee could not be appointed to carry out his suggestion.

The meeting then concluded.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, APRIL 11TH, 1885, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

JOHN DAGLISH, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated :—

HONORARY MEMBER—

Mr. Principal GARNETT, M.A., Durham College of Science, Newcastle-upon-Tyne.

ASSOCIATE MEMBER—

Mr. J. MATTHEWS, Messrs. R. & W. Hawthorn, Newcastle-upon-Tyne.

STUDENT—

Mr. WILLIAM ASHLEY SHUTE, Westoe, South Shields.

The following gentlemen were nominated for election :—

ASSOCIATE MEMBERS—

Mr. JOHN FORSTER LEE, Castle Eden Colliery, Co. Durham.

Mr. EDWARD HALSE, Assoc. R.S.M., Arenig Mines, Bala, North Wales.

STUDENT—

Mr. A. D. NICHOLSON, Mining Student, Eldon Colliery, Co. Durham.

The following paper, by Mr. C. C. Leach, "On the Shrinkage of Paper," was read :—

ON THE SHRINKAGE OF PAPER.

By Mr. C. C. LEACH.

The writer's attention was first drawn into an examination of this subject in 1882, from having accurately marked off a large square upon paper one afternoon, and finding it next morning measurably out of the square, all the sides having altered in length; and also from seeing that adjacent edges of some tracings off the original MS. Ordnance plottings were so widely different in length as not to join accurately together.

That paper is liable to shrinkage is a fact admitted by those who use it; but perhaps its extent and erratic variations are not so widely known nor so closely watched as their importance warrants.

In answer to inquiries as to the best way to avoid or lessen shrinkage, the makers of Whatman's paper wrote, saying:—"We think your best plan would be to find out from some one who is in the habit of mounting paper for plans, etc., how the shrinkage is to be avoided, as we cannot possibly guarantee our papers not shrinking, although we suppose they do not to any extent, or we should have had complaints about it."

Plan mounters say:—"Paper may shrink, but after mounting and thoroughly drying (from three to six weeks) it cannot shrink, the paste and holland holding it together."

Another paper maker says:—"If used as we send it away from the mill, we think there will not be any expansion or contraction."

Another paper maker, who has made experiments with regard to shrinkage, writes:—"Your remarks (as to the uneven shrinkage) about hand-made papers are perfectly correct, for they vary very much indeed, and it is a great defect that must always accompany that description of paper. Some years since we studied that peculiar fault in drawing and chart papers, and succeeded in reducing it to a minimum, for it never can be entirely avoided. . . . . Whatever pains are taken, the wetting, gumming, or pasting the paper for mounting must always tend to alter the relative positions of some of the fibres, and give uneven shrinkage." They consider strength, perfect sizing, uniformity and absence of hairs as indispensable qualities.

Professor C. Piazzi Smyth writes, saying:—"I never trusted paper for any important measure; and as to my plans and sections of Great Pyramid as drawings, warned the public not to trust them for any finalities, to use them only as indexes and primers, and refer to the recorded measurements in numerals wherever accuracy was desired; so I made and recorded no measurements as to how much paper expanded and contracted under divers circumstances, or the kinds of paper, but considered them all unsafe to a greater or less degree."

The writer noted down, from time to time, the variations in size of hand-made and machine-made papers, mounted and unmounted, under various conditions, upon paper in stock and plans lying by as well as when work was being put on them. All the plans were kept in cases in an upper office against inner walls.

In all the following investigations points were marked off on the paper at exactly measured distances, using the same mahogany-boxwood feather-edged scale $\frac{1}{2500}$ and 120 chains long.* A wooden scale being chosen as it is less liable to alter in length than an ivory one. It was kept in a wooden case beside the plans. Every measurement was recorded in links, any increase in length of the paper above the distance first marked off was set down with the plus sign before it, and any decrease in length with the minus sign prefixed; the figures, therefore, always showing the exact increase or decrease in links from the original setting off. Most of the points were exactly 120 chains apart. In those that were not, the results are calculated to their equivalents of 120 chains to facilitate comparison.

As figures are difficult to follow, the writer has prepared diagrams, on which are recorded the variations of each measurement represented by dotted lines of different patterns, and the average by a continuous black line; the thick horizontal line is the zero line, or size as first originally measured off; each square in height is one link, those above the zero line being the plus figures, or enlargements, and those below the minus figures, or contractions of the paper from the original measurement; every second vertical line ends the month (or day).

Plate XXV. is a diagram of measurements made on Whatman's hand-made sheets, unmounted. Each pattern of dotting is for a separate sheet, the lines of the like pattern but of different strength marked *aa*, *bb*, &c., being different measurements at right angles on the same sheet, which clearly shows there is no uniformity of change even in the same sheet of paper.

* To this scale 120 chains are equivalent to 37·920 inches, and 1 link (7·92 inches) is equivalent to ·00316 of an inch on the paper; this makes a variation of 25 links on the scale equal ·079 of an inch on the paper.

Plate XXVI. is a diagram of machine-made or cartridge paper, unmounted. The above remarks apply here.

Plate XXVII. is a diagram of tracing paper. The above observations apply here also.

Plate XXVIII. is a diagram of a spare plan in stock made on Whatman's hand-made paper, mounted; each pattern of dotting is for separate spaces measured, there being four distinct distances measured on various parts of the plan, showing a similar variety of movement to that of unmounted paper.

Plate XXIX. is a diagram of Whatman's hand-made paper, mounted, 15 years old, in use, showing similar variations as above recorded, so that this length of time does not stop the movements of the paper.

Plate XXX. is a diagram of Whatman's hand-made paper, mounted, recently obtained, upon which surface and underground workings were plotted, and then left for the succeeding 18 months with but little plotting done to it. The bi-monthly measurements recorded show extensive variations in some of the distances measured, and little variation in others at the same time, and a very marked shrinkage on the average.

Plate XXXI. is a diagram of Whatman's hand-made paper mounted, in daily use, showing daily alterations in size while being plotted on, the greatest range of variation being 28 links, and of the average line 15½ links. The thick lines show the movements of the plan during the day, and the thin lines during the night; showing, almost invariably, that the plan shortens during the day, and that it lengthens at night.

Plate XXXII. is a diagram of cartridge paper, unmounted, in daily use, showing daily alterations in size while being plotted upon, the greatest range of variation being 19 links, and of the average line 12½ links. The thick lines showing the movements of the paper during the day, and the thin lines the night movements; which are less in range of variation than those in each direction, shown in Plate XXXI., while the variations are more in unison.

Plate XXXIII. is a diagram showing the average lines of the six first diagrams and their common average.

From measurements made on plans laid by in the plan case during the day time the shrinkage from morning till evening is only 2 or 3 links, which is very much less than when lying out on the table, or when work is being put on. The bi-monthly measurements were mostly made in the afternoons; those months in which the measurements were made in the morning will alter the comparisons a little.

From these diagrams (and others) it is evident every kind of paper

is ever expanding and contracting sensibly, and often to a very important extent, and that these variations are of two kinds, namely, a yearly and a daily one.

Tracing cloth movements have been left out altogether, as the cloth stretches so much in being smoothed out by the hand.

YEARLY MOVEMENTS.

	Least Size Averages.		Greatest Averages.		Range of Averages.	
	August, 1883.	June, 1884.	February, 1883.	December, 1884.	1883.	1884.
Diagram I.—Hand-made sheets, unmounted ...	+ 1	+ 5	+ 13	+ 15½	12	10½
„ II.—Cartridge sheets, unmounted	− 1	+ 2¼	+ 10	+ 10	11	7¾
„ III.—Tracing paper sheets, unmounted ...	+ 0¼	+ 6¾	+ 11	+ 12¾	10¾	6
	June		Oct.	Nov.		
„ IV.—Hand-made, mounted	− 1½	− 1	+ 7¾	+ 11½	9¼	10½

Which is slightly in favour of the cartridge paper. All the plans were least in size in June, 1883, and June, 1884, and largest in October, 1883, and December, 1884. (See Plate XXXIII.)

DAILY MOVEMENTS.

	Extremes.	Extremes Range.	Largest Averages.	Average Range.
Diagram VII.—Hand-made paper, mounted	+11−17	=28	+7−8½	=15½
„ VIII.—Cartridge, unmounted ...	+10− 9	=29	+7−5	=12½

Again in favour of cartridge paper.

Damp expands paper, but very unequally; in some cases of paper, stretched on the drawing boards, five times as much one way as another. The papers varied in size while glued on to the boards, and after being cut off, followed the usual bi-monthly alterations.

The director of the Ordnance Survey at Southampton said, respecting some MS. tracings, that if they were tried on the plans off which they were traced, he did not expect they would fit, and that it was with the greatest difficulty they could get their sheets to stand while being plotted, which practically means that they do not and cannot prevent them altering in size. He said it was a good thing to let the paper lie out and dry on the table three or four hours before using it. This is so, for as soon as it is laid out it begins shrinking.

In their London office, all the preparation is done by the line plotter himself (if he thinks that the paper is at all damp), by taking as many sheets as required, and spreading them out, or folding them loosely and separately, and placing them near the fire in his room for a few hours to dry them. And this is all he does.

A Manchester architect told the writer that he never used paper for any special work that he had not kept in stock 10 years (machine-made paper mounted in the roll was spoken of), when he expected the movement would be very little. But 15 years does not stop hand-made mounted paper from varying considerably, as already stated. (See Plate XXIX.)

The moisture in the air doubtless affects the paper, and the breath also causes local alterations, and perhaps the pressure of the hand, etc.; but the two latter cannot, by any means, account for all the shrinkages on other parts of the plan, on which no work, nor breath, nor weight of any kind comes in contact, nor in those plans which are not in use.

From hygrometric observations, the air in the office was drier in the evening than it was in the morning, in 97 cases out of 100, by 1 degree to 2 degrees; and this is probably the chief reason for the almost invariable decrease in the size of the plans in the evening, from their getting drier: and also for their expansion in the night time, as the air gets damper again. (See Plates XXXI. and XXXII.)

The yearly movements are also doubtless due to the above cause, namely, the varying relative humidity of the air during the year.

The following Table gives the mean monthly percentage of the relative humidity of the outside air at North Shields, for 1883-84, and also the average for the last 10 years. Saturation is 100.

MEAN MONTHLY PERCENTAGE OF THE RELATIVE HUMIDITY OF THE OUTSIDE AIR AT NORTH SHIELDS.

Months.	1883. Per Cent.	1884. Per Cent.	1875-84. 10 Years Average. Per Cent.	Remarks.
January ...	91	84	89	Most moist months.
February ...	90	86	89	
March	89	87	86	
April	82	87	85	
May	74	72	78	Dryest month.
June	88	80	82	
July	84	84	81	
August ...	82	83	85	
September ...	90	91	87	
October ...	89	88	88	
November ...	89	88	88	
December ...	85	87	88	

See Plate XXXIV.

COMPARISON OF RELATIVE HUMIDITY WITH SIZE OF PLANS.

Years.	Outside Air is most Absorbent in.	Plans Average, (see Plate XXXIII.) Least Size on.	Outside Air is least Absorbent in.	Plans Average, (see Plate XXXIII.) Largest Size on.
1883	May	June 30	January and February	October 25
1884	May	June 30	September	December 21
1875–84	May	...	January and February	...

The plans are about their largest size during the most humid months, and least during dryer ones. Probably the relative humidity of the air inside the office is very similar to that of the outside air. (See Plate XXXIV.)

From the foregoing it appears that :—

1.—Machine made papers vary less, and less unevenly, than hand-made sheets.

2.—Mounted paper varies very much more unequally than unmounted, and to a greater extent.

3.—New paper, and especially newly mounted paper, varies more and more unequally than older, and older mounted plans.

4.—All papers mounted or unmounted irrespective of age, continually vary in size.

5.—No two plans vary exactly alike.

6.—The yearly and daily variations are similar for all plans.

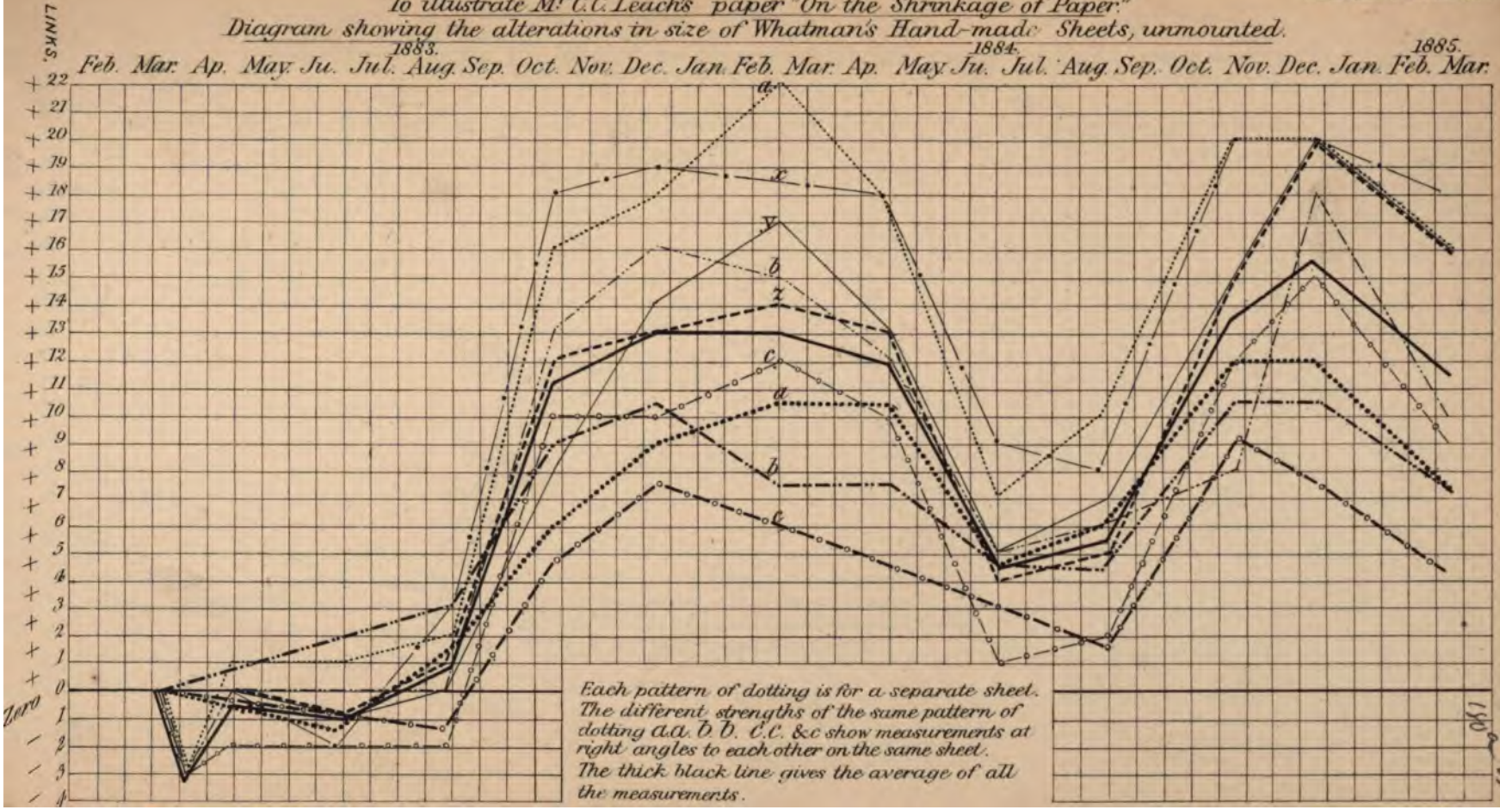
7.—Making a scale on the paper as an accurate standard of measurement is all but useless, as different parts of the same plan vary in size so differently at most times.

8.—In conclusion, the very uneven and changing alterations in the sizes of plans, which twist the base lines, and otherwise affect their general accuracy, are of sufficient importance for the extent to be ascertained, and, if practicable, for some means to be devised for obviating these variations.

Numerals, as suggested by Professor C. Piazzi Smyth, cannot be used, but the colliery plans themselves have to be referred to for accuracy; it therefore appears advisable to fix on every important plan, points at measured distances on several parts of it, so as to be able to observe at any time, and especially before any large special survey be laid down, whether the plan is within reasonable limits of its original size.

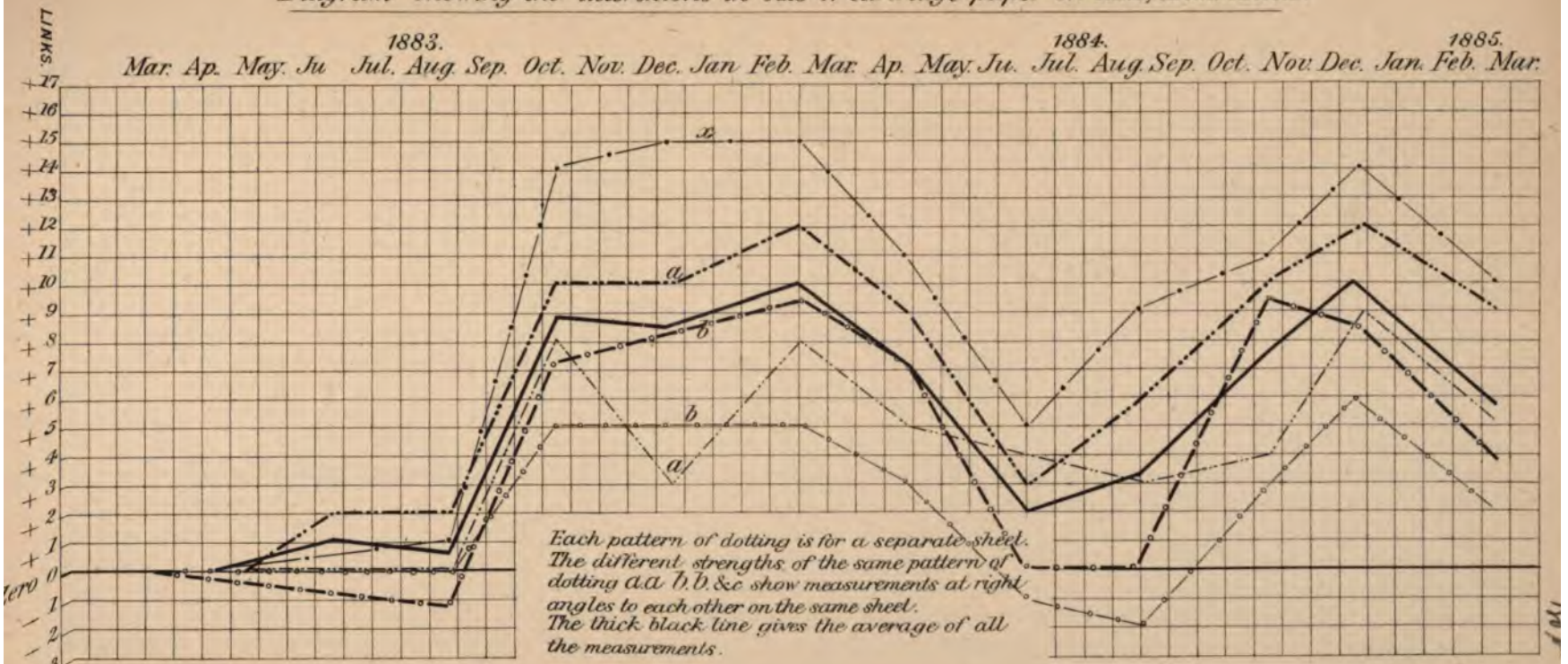
To illustrate Mr C.C. Leach's paper "On the Shrinkage of Paper."

Diagram showing the alterations in size of Whatman's Hand-made Sheets, unmounted.


1883.
1884.
1885.
Feb. Mar. Ap. May Ju. Jul. Aug. Sep. Oct. Nov. Dec. Jan. Feb. Mar. Ap. May Ju. Jul. Aug. Sep. Oct. Nov. Dec. Jan. Feb. Mar.
INCHES
+ 22 + 21 + 20 + 19 + 18 + 17 + 16 + 15 + 14 + 13 + 12 + 11 + 10 + 9 + 8 + 7 + 6 + 5 + 4 + 3 + 2 + 1 + 0 Zero 1 2 3 4
a
x
y
b
z
c
a
b
c
Each pattern of dotting is for a separate sheet.
The different strengths of the same pattern of dotting a.a. b b. c.c. &c show measurements at right angles to each other on the same sheet.
The thick black line gives the average of all the measurements.

To illustrate Mr C. C. Leach's paper "On the Shrinkage of Paper."

Diagram showing the alterations in size of Cartridge paper off Roll, unmounted.

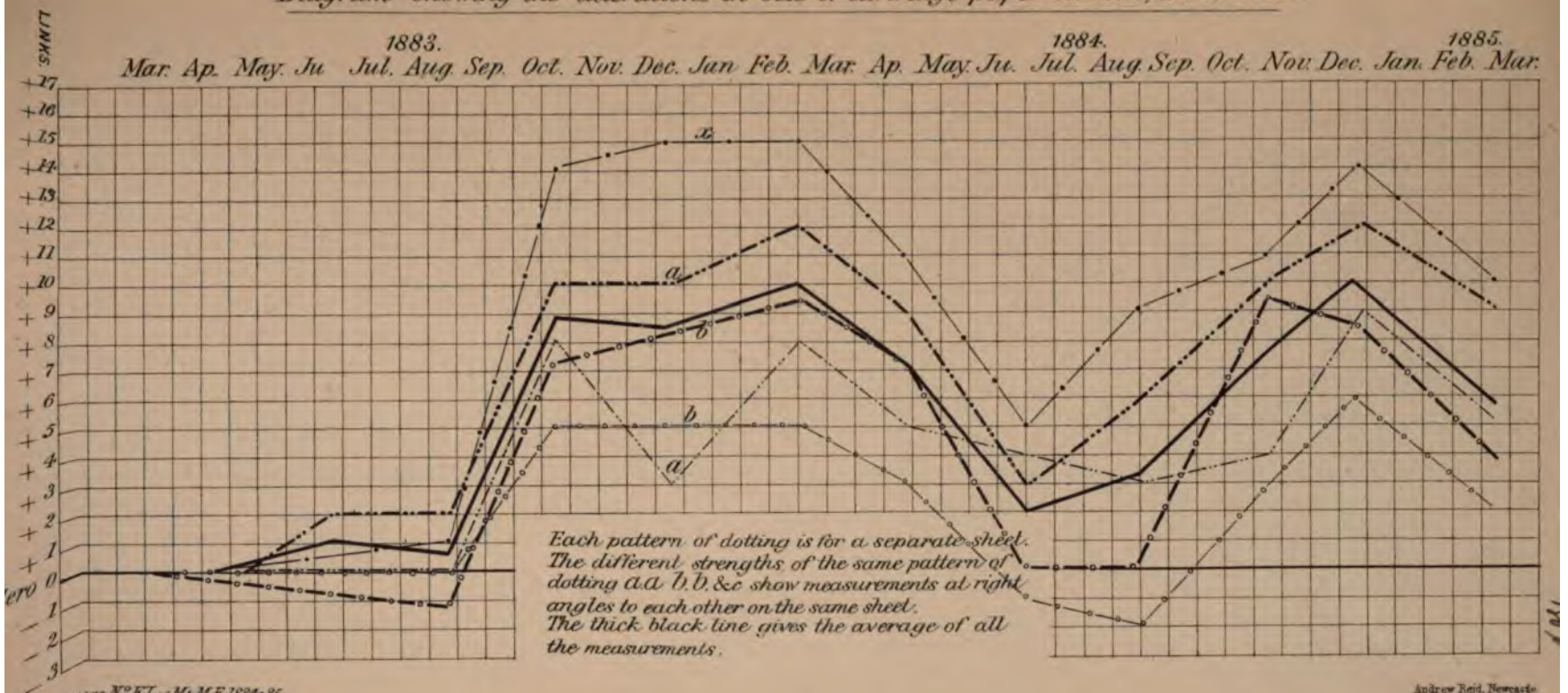


Proceedings N° E1 of M. & M. E. 1884-85.

Andrew Reid, Newcastle.

To illustrate Mr C. C. Leach's paper "On the Shrinkage of Paper."

Diagram showing the alterations in size of Cartridge paper off Roll, unmounted.

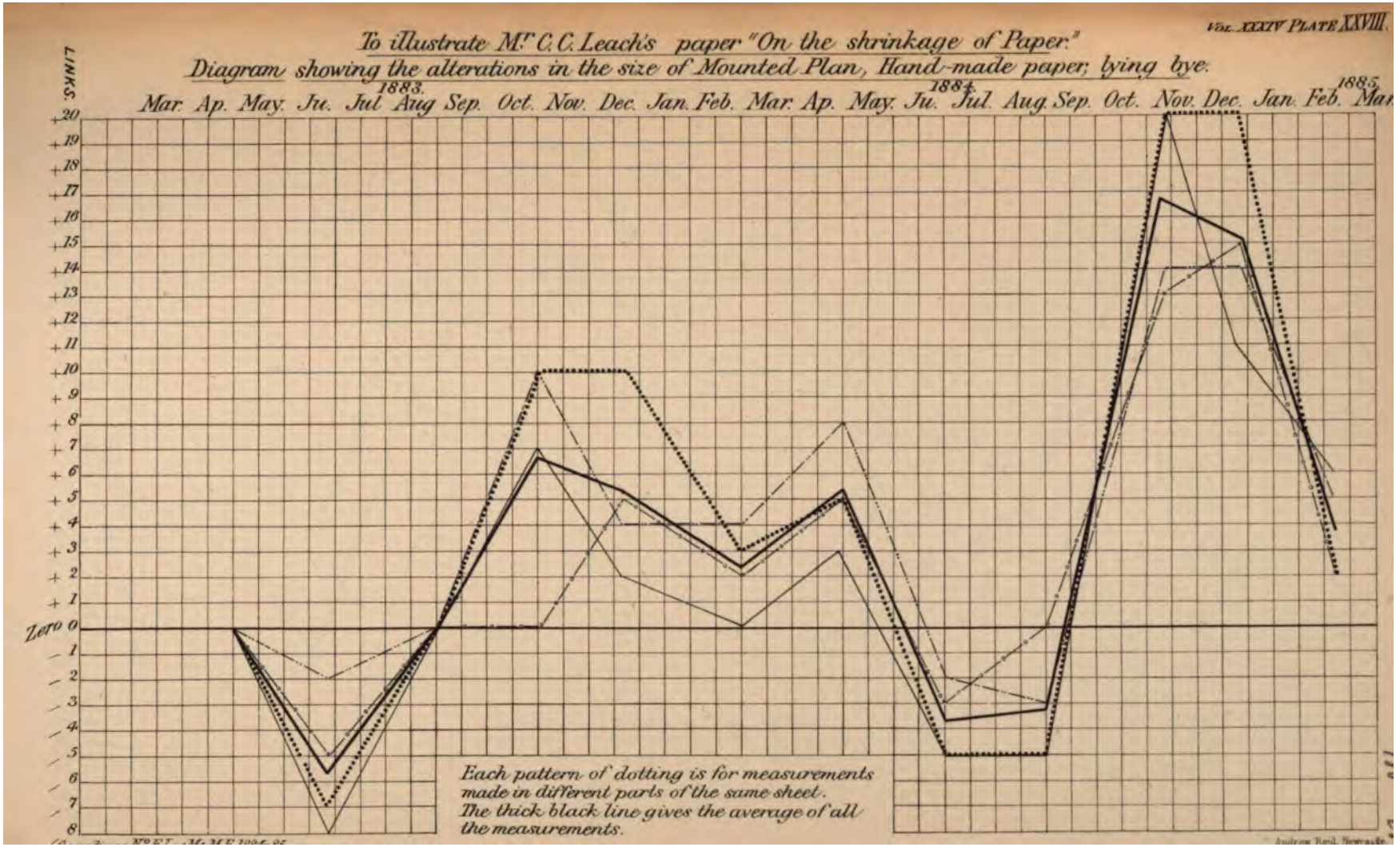


Proceedings N° E.I. of M&M.E. 1884-85.

Andrew Reid, Newcastle.

To illustrate Mr. C. C. Leach's paper "On the shrinkage of Paper."

Diagram showing the alterations in the size of Mounted Plan, Hand-made paper, lying bye.



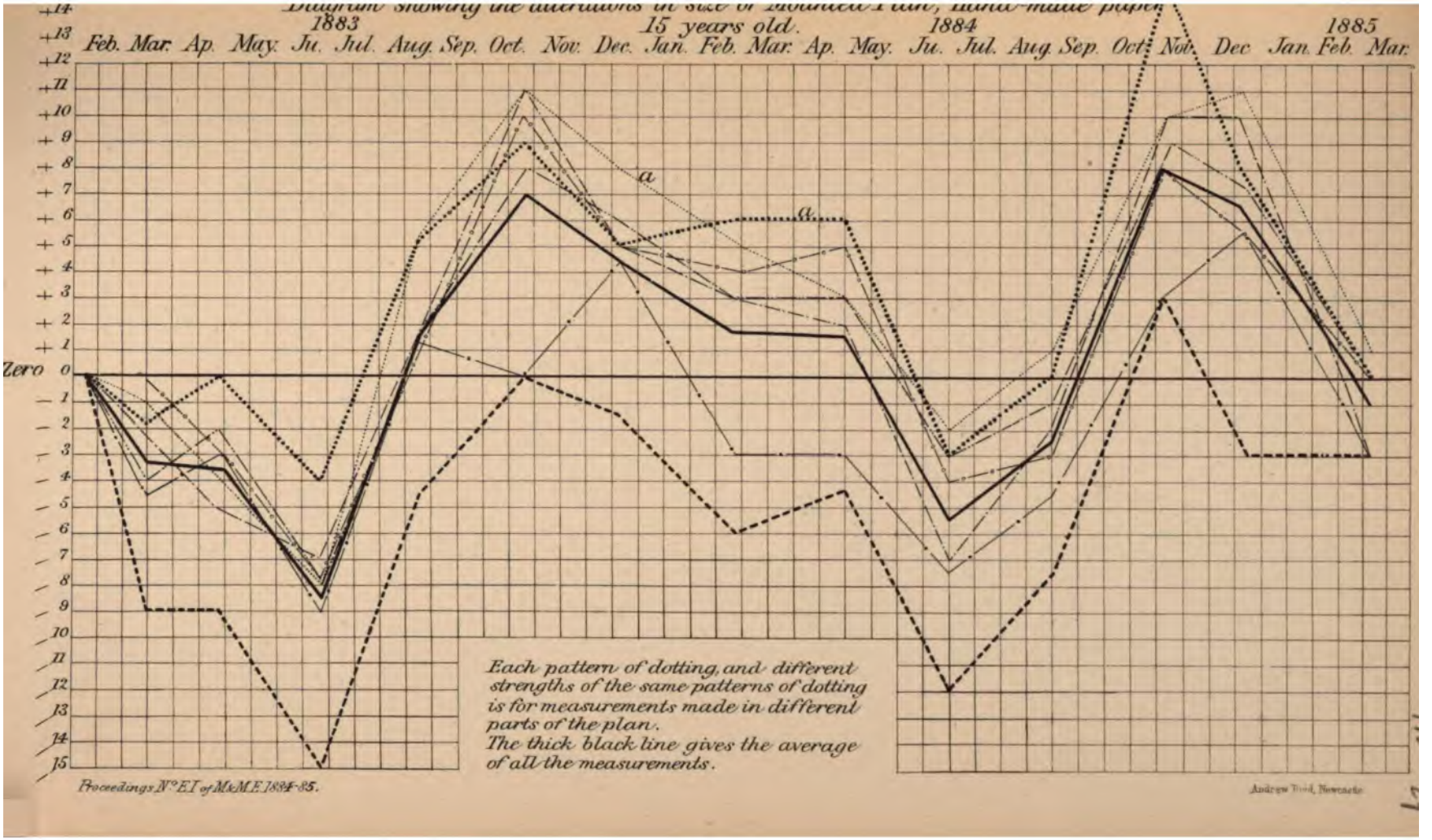
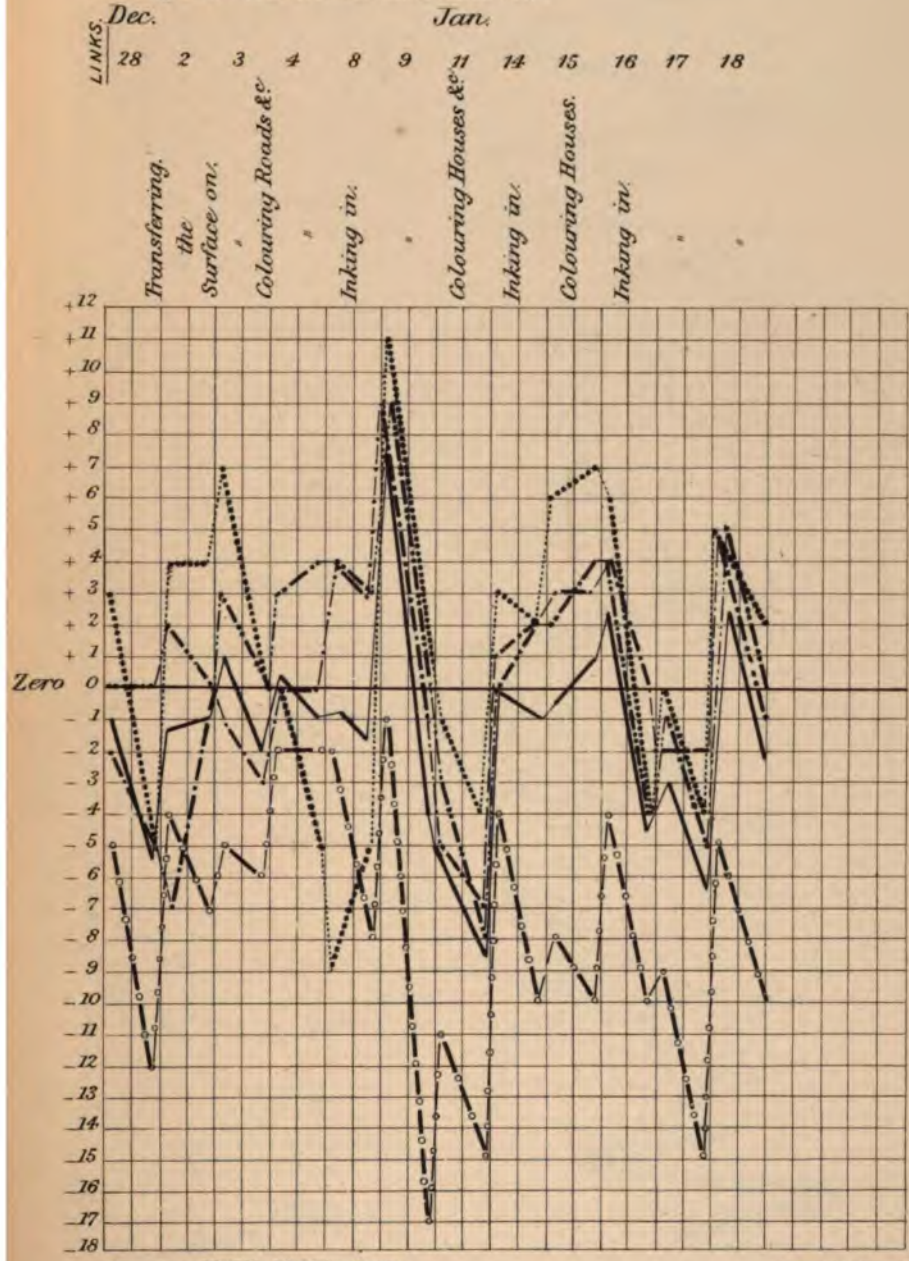


Diagram shewing the alterations in size of Bonded Plan, hand-made paper
1883
15 years old.
1884
1885
Feb. Mar. Ap. May. Ju. Jul. Aug. Sep. Oct. Nov. Dec. Jan. Feb. Mar. Ap. May. Ju. Jul. Aug. Sep. Oct. Nov. Dec. Jan. Feb. Mar.
+14 +13 +12 +11 +10 + 9 + 8 + 7 + 6 + 5 + 4 + 3 + 2 + 1
Zero 0
— 1 — 2 — 3 — 4 — 5 — 6 — 7 — 8 — 9 — 10 — 11 — 12 — 13 — 14 — 15
a
a
Each pattern of dotting, and different strengths of the same patterns of dotting is for measurements made in different parts of the plan.
The thick black line gives the average of all the measurements.
Proceedings N°E.I of M&M.E 1884-85.
Andrew Reid, Newcastle

To illustrate Mr. C. C. Leach's paper "On the shrinkage of Paper."

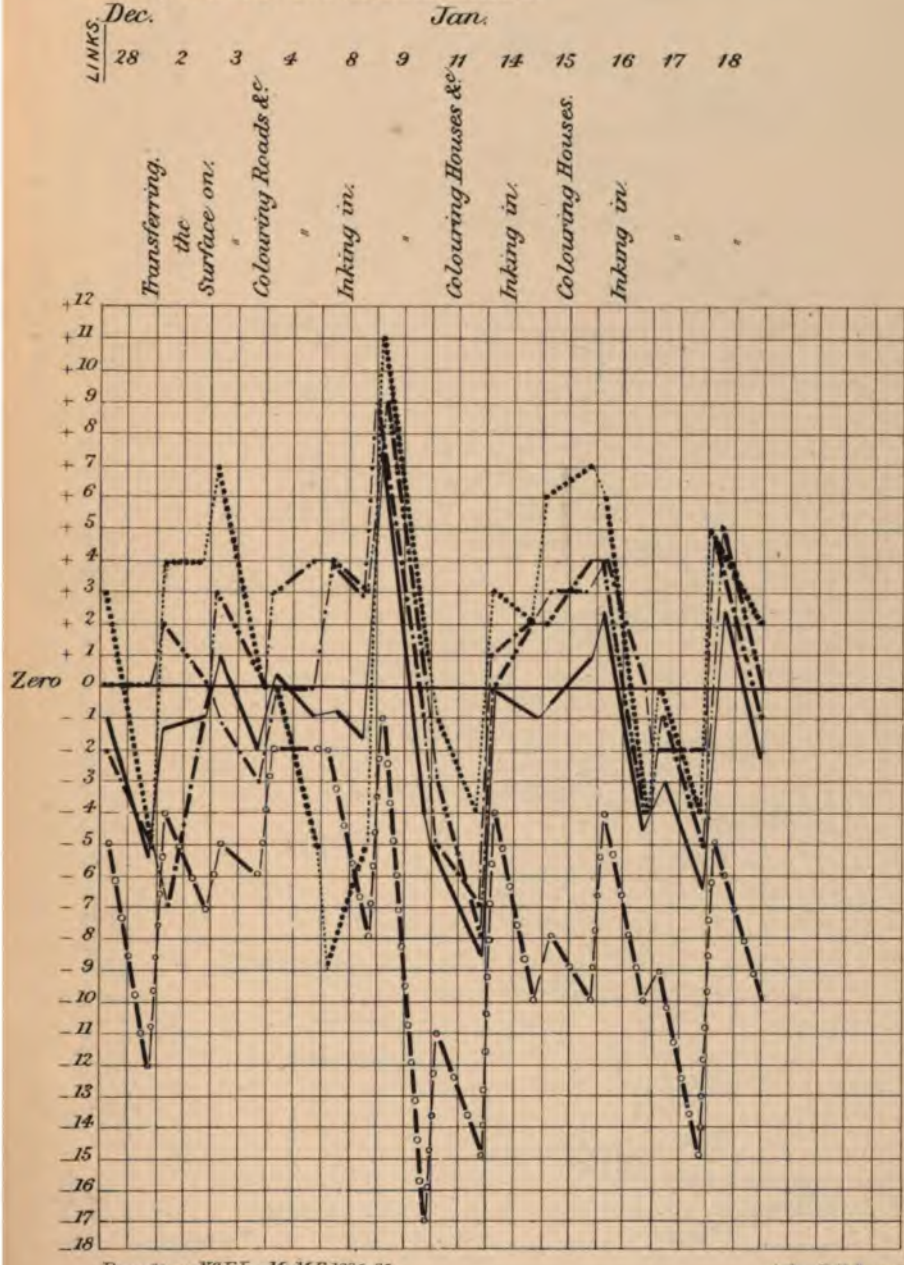
Diagram showing the alterations in size of Mounted Plan, Hand-made paper, while being made. Thick lines variation from morning till evening. Continuous black line gives the average of all the measurements.



Andrew Reid, Newcastle

To illustrate Mr. C. C. Leach's paper "On the shrinkage of Paper."

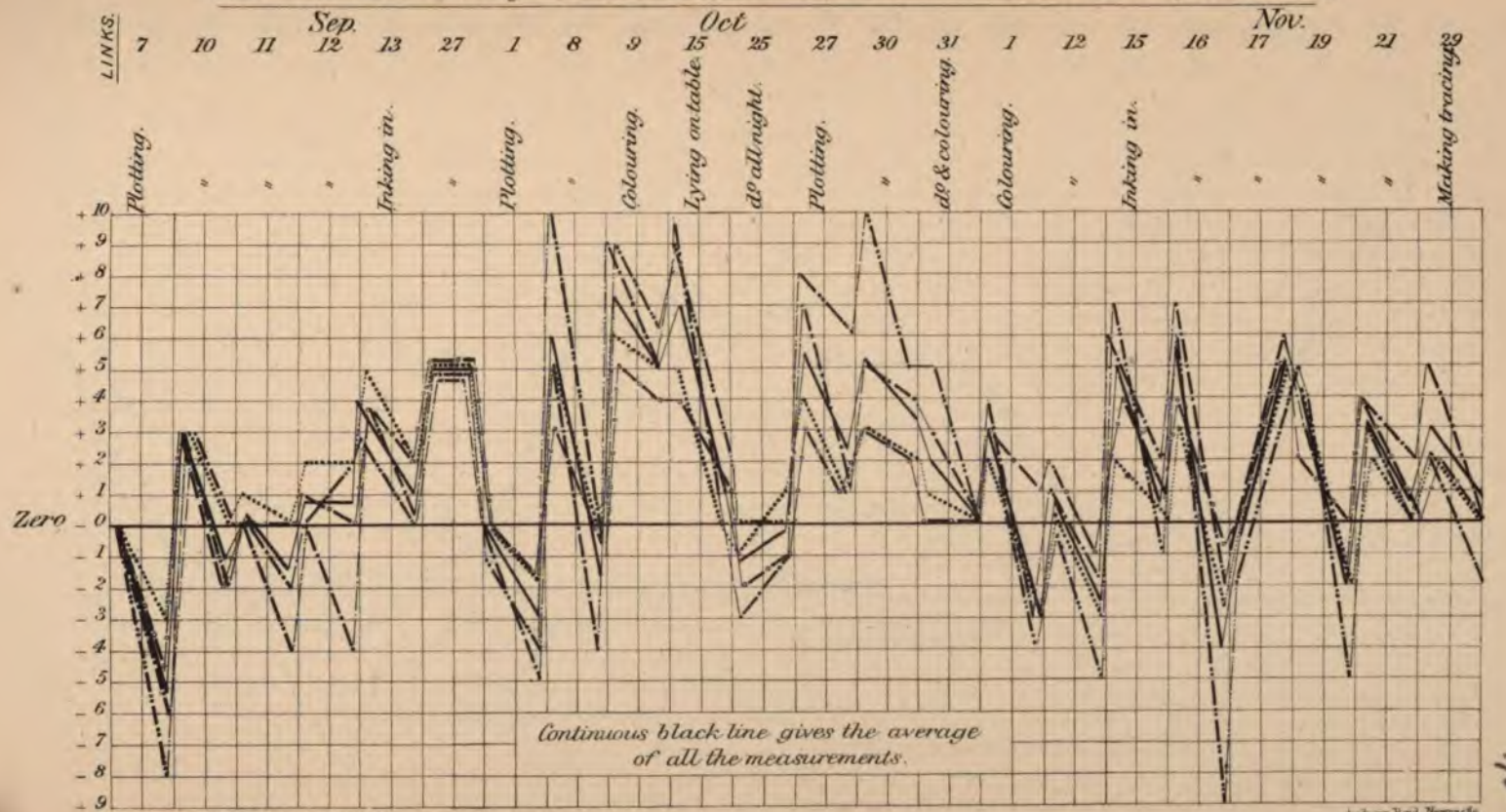
Diagram showing the alterations in size of Mounted Plan, Hand-made paper, while being made. Thick lines variation from morning till evening. Continuous black line gives the average of all the measurements.



Andrew Reid, Newcastle.

To illustrate Mr. C. C. Leach's paper "On the Shrinkage of Paper."

Diagram showing the alterations in size of Unmounted Plan, Cartridge paper, while the Plan was being made. Thick lines are the variation from morning till evening.


Sep.
Oct
Nov.
LINKS.
7 10 11 12 13 27 1 8 9 15 25 27 30 31 1 12 15 16 17 19 21 29
Plotting. " " " Inking in. " Plotting. " Colouring. Lying on table. do all night. Plotting. " do & colouring. Colouring. " Inking in. " " " " Making tracings.
+10 +9 +8 +7 +6 +5 +4 +3 +2 +1
Zero 0
-1 -2 -3 -4 -5 -6 -7 -8 -9
Continuous black line gives the average of all the measurements.

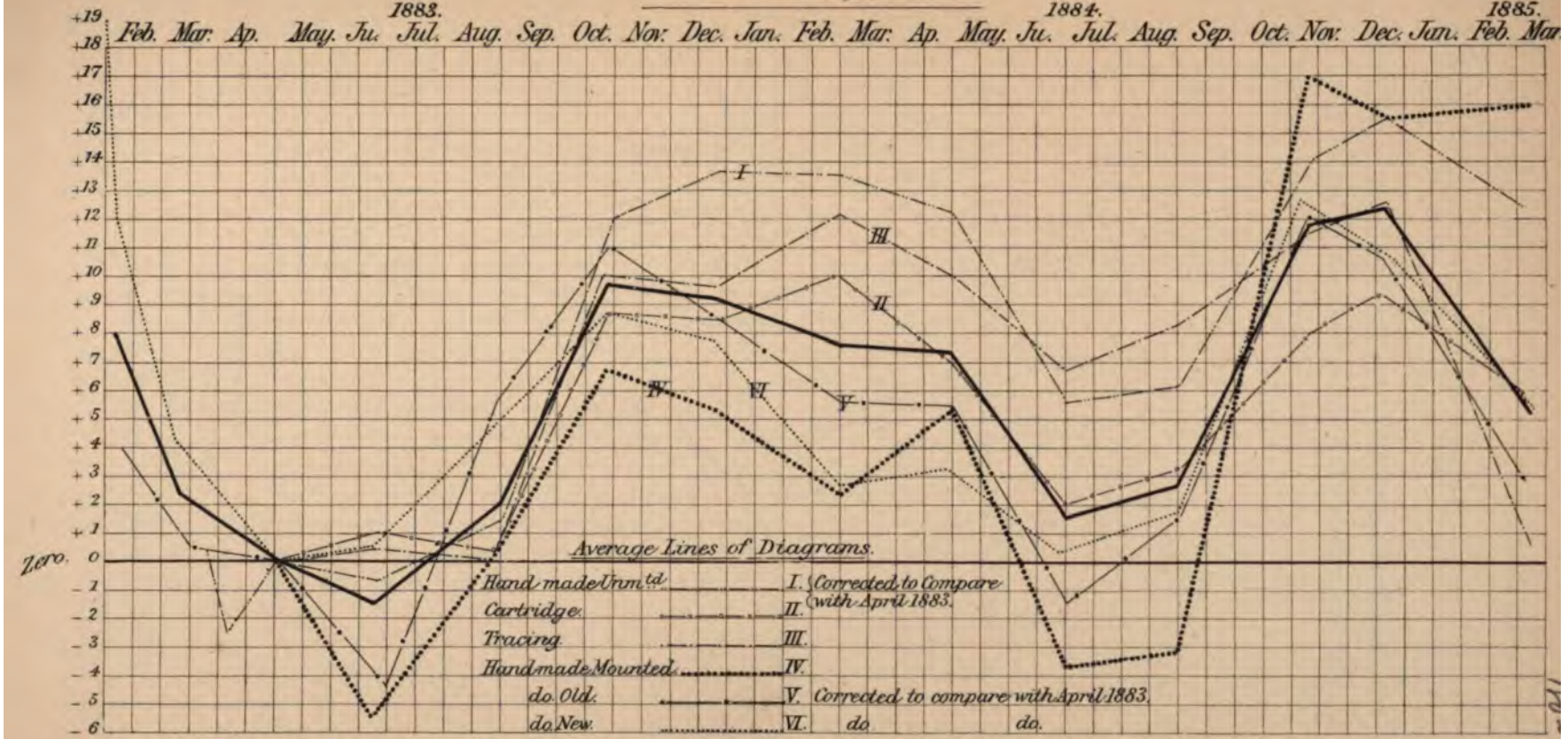
Proceedings N° E.I. of M.s M.E. 1884-85.

Andrew Reid, Newcastle.

37
1902

To illustrate Mr. C.C. Leach's paper "On the Shrinkage of Paper."

Diagram showing the average alterations in size of the lines shown in the various Diagrams.


Links.
1883.
1884.
1885.
Feb. Mar. Ap. May. Ju. Jul. Aug. Sep. Oct. Nov. Dec. Jan. Feb. Mar. Ap. May. Ju. Jul. Aug. Sep. Oct. Nov. Dec. Jan. Feb. Mar
+19 +18 +17 +16 +15 +14 +13 +12 +11 +10 +9 +8 +7 +6 +5 +4 +3 +2 +1 0 −1 −2 −3 −4 −5 −6
Zero.
I.
II.
III.
IV.
V.
VI.
Average Lines of Diagrams.
Hand-made Drm.td I. Corrected to Compare with April 1883.
Cartridge II.
Tracing III.
Hand-made Mounted IV.
do Old. V. Corrected to compare with April 1883.
do New. VI. do do.

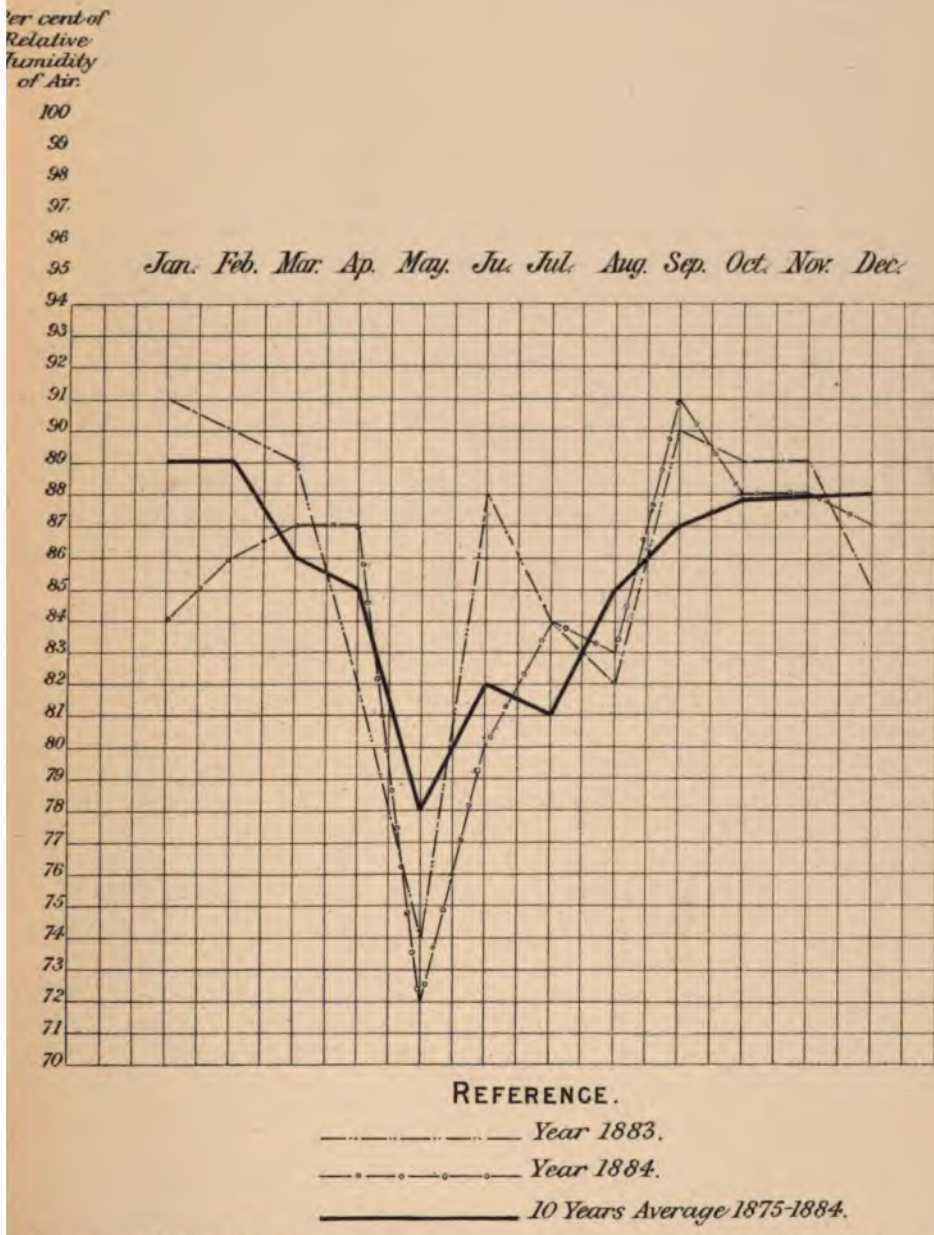
The thick black line gives the average of all the measurements.

Proceedings N° E.I of M.M.E. 1884-85

Andrew Reid, Newcastle

To illustrate Mr C.C. Leach's paper "On the Shrinkage of Paper."

Diagram showing the Mean Monthly Percentages of Relative Humidity at N. Shields (Saturation being 100) for 1883 and 1884; and the average for 10 years, viz: 1875-1884.



Andrew Reid, Newcastle.

The PRESIDENT said, they had heard read a very exhaustive paper on an important subject, a subject to which, perhaps, sufficient attention had not been paid hitherto. The discussion of the paper would be reserved until another day. He proposed a vote of thanks to Mr. Leach for the paper.

Mr. W. G. LAWS had great pleasure in seconding the vote of thanks to the writer of the paper. He thought this was a subject of great interest to engineers and surveyors, and one he had known of for the last thirty years. He believed it was more than forty years since some of the London mathematical instrument makers took up the subject, and one person proposed to use scales of paper for the sake of avoiding this shrinking, which was then recognized, but of the extent of which they were not aware of. What Mr. Leach had written about was nothing new, but he believed he was the first one who had taken pains in arriving at accurate results on the matter, and had given the members something by which they could judge.

The motion was unanimously agreed to.

The following paper, by Mr. Joseph Routledge, "On the Routledge and Johnson Double Combination Miners' Safety-Lamp," was read:—

ON THE ROUTLEDGE AND JOHNSON DOUBLE COMBINATION MINERS' SAFETY-LAMP, Nos. 1 AND 2.

By J. ROUTLEDGE.

Ever since the introduction of safety-lamps in coal mines, seventy-two years ago, by those illustrious men, Davy, Stephenson, and Clanny, the question of improving them has received constant attention by various individuals, and by the several mining societies throughout the kingdom.

The long known insecurity of these lamps under certain conditions has been pointed out many times, and repeated efforts have been made by some hundreds of inventors to make a safe lamp, or at least a lamp in which confidence can be placed, but the results heretofore cannot be deemed satisfactory, more especially when the improvements made in other branches of mining are considered; and in contrasting the enormous volumes of air which are circulated through modern mines with what was considered sufficient in days gone by, together with other changes which are obvious to mining men, it is very evident that the conditions of danger to which safety-lamps are exposed are materially altered and aggravated.

As to the original lamp of either Davy or Clanny, it cannot be said that, even when used simply to test a standing body of gas, or when exposed in an explosive mixture at a low velocity, its safety is free from doubt; whilst, if kept a short time in such a mixture, it would generally explode the surrounding gas. This is, however, a condition not much to be feared, testing for gas being generally done by careful persons.

In a mine giving off inflammable gas, the circumstances under which the greatest danger is to be apprehended may be described as follows :—

1.—A person travelling the mine, suddenly finding himself among gas, his lamp filled with flame, and the gauze becoming red hot, impulsively runs back, and so causes a velocity sufficient to pass the flame through the gauze.

2.—It frequently occurs that heavy falls of roof in the goaves drive down large volumes of gas into the level of the mine, and the gas may completely surround a person before he can make good his retreat. In this case there is a twofold danger—first, from the current created by the fall; and, second, by the person rushing out among the gas from his working-place.

3.—Outbursts, or blowers, of gas have been known to fill the galleries of a mine in a very short period, and large volumes of air have been rendered into a mixture which, if ignited, would have had the most dire consequences, but no explosion has occurred, either because the lamps extinguished themselves, or the mixture moved at such a low velocity as to allow the men to withdraw before the lamps became red hot.

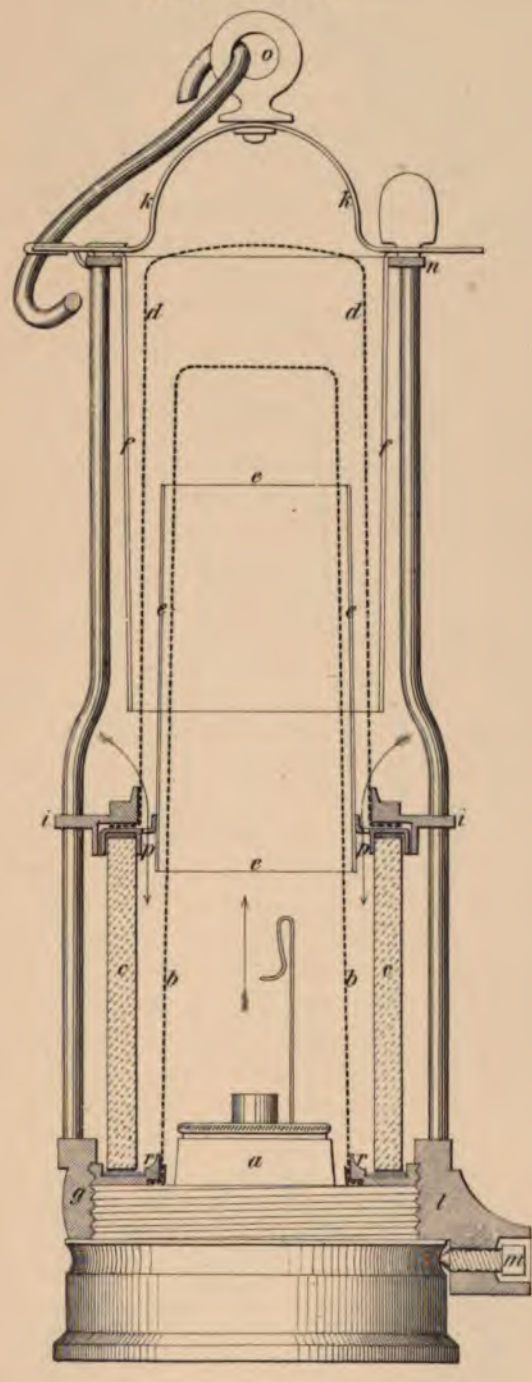
There are also many other incidents and dangerous conditions which lamps are liable to, amongst which may be enumerated those from stone and coal flying from the blows of picks; from pieces of coal and stone slipping from a shovel when a workman is in the act of filling; from the blow of a hammer displacing a nail, a piece of wood or coal, which may fly and break the glass; from falls of stone and coal; from the slipping and rebounding of wedges while being driven into hard rock; from water being splashed on a highly heated glass and shivering it, etc., etc. These are incidents, mainly of an accidental nature, which from time to time come under the notice of mine managers and cause them a great amount of anxiety. It is true that rules and regulations, over and above the general and special rules, are instituted, and advice given, with a view of providing against the occurrences above described, but they still occur, and may be attended with disastrous results.

The question then arises, Can not a useful lamp be made with a much higher ratio of safety than any at present in use? A negative answer has been given by the Ellis Lever Committee and by the experiments of other authorities, with the exception that one or two lamps, which certainly have claims to a little more safety, and are an improvement on the past, have been made known; still that ratio of safety is not large enough, nor is it in keeping with other colliery appliances, which are, as a rule, fully equal to or beyond the work; neither does the construction of these lamps meet the approval of many colliery managers and their workmen.

All these points having been most carefully considered by the writer and Mr. Johnson, it was thought it might be possible to make a lamp to combine all the best features of those which have been known so long

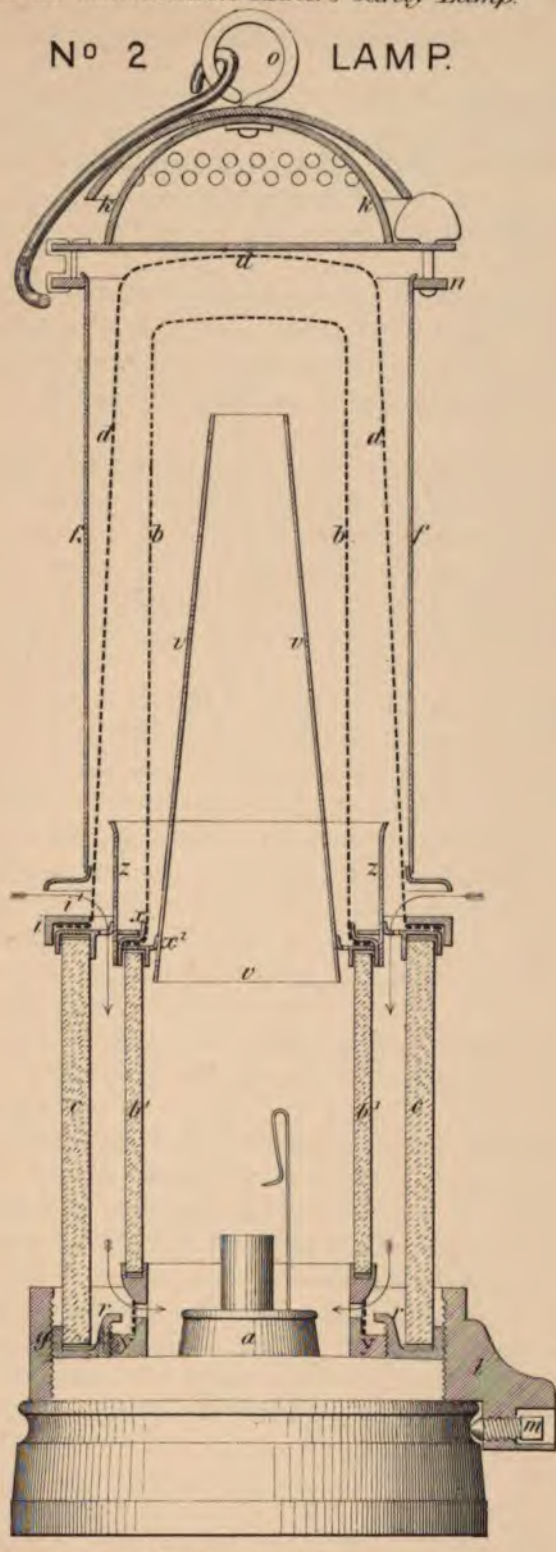
To illustrate Mr. Routledge's paper "On the Routledge and Johnson Double Combination Miner's Safety Lamp." 1884

No. 1 LAMP.



Scale ¾ Size.

To illustrate Mr. Routledge's paper "On the Routledge and Johnson Double Combination Miner's Safety Lamp." 1884



Proceedings N° E.I. of M.&M.E. 1884-85. Scale ¾ Size. Andrew Reid, Newcastle.

in our collieries with the best principles revealed in the course of recent experiments, and, at the same time, to have it arranged as a sort of double lamp, so that if any external parts were damaged by accident, or the glass not fitting properly, the lamp would still be quite safe.

The following is a description of the double-combined safety-lamps, Nos. 1 and 2 :—

No. 1 lamp (Plate XXXV.) has an ordinary oil vessel and wick tube *a*, surrounded by a Davy gauze *b*, then these in their turn are covered by a Clanny glass *c*, surmounted with a gauze cylinder *d*, both the Davy gauze *b* and the gauze cylinder *d*, being protected by shields *e* and *f*.

These various portions are held together in the following simple way:— *g* is a sort of foundation ring which screws on to *a*, and has attached to it the projection *l* which carries the locking screw *m*, three or four pillars start from this and are secured to a ring *i*, about one-third of the total height of the lamp, other pillars again spring from this ring which support a ring *n*, forming the top of the lamp, to which is fixed the bonnet *k* and ring *o* in the usual way.

The shield *f* is inserted through the top of the ring *n*, and is kept in its place by the bonnet *k*. The gauze cylinder *d* is then put in from below where its flanged part fits into a recess in the ring *i*, made expressly to hold it. The shield *e*, to which is attached a ring *p*, is then inserted from below, the glass *c* is then put in and secured by the ring *r* which is screwed on to it. The glass has leather or asbestos washers both above and below, and lastly, the Davy gauze *b* is inserted and securely nipped between the lamp *a* and the ring *r*.

The ring *p* has 24 holes, one-sixteenth of an inch diameter, through which air is admitted, as shown by the arrow.

The arrangement in this lamp meets the objections of many veteran pitmen, who oppose the idea of having only a glass between the light and an explosive mixture.

No. 2 lamp (Plate XXXVI.) is of the same general principle, but in order to give the greatest possible amount of light, a second glass b^1 is made to form the bottom of the gauze *b*, inside this gauze is a conical tin chimney *v*, and outside it, for a short distance up, a tin ring *z*. The foundation ring *g*, is fixed to the centre and top rings *i* and *n*, in the same way as in lamp No. 1, the centre ring, however, is made to receive the gauze cylinder *d* and the short tin cylinder *z*, together with an asbestos or leather washer to secure the glass *c*, all of which are tightened up and kept in their places by the screw *r*. The ring *i* is divided on its periphery by a slit i^1

for the admission of air which passes onward to the lamp, through the flange of the tin cylinder z which is perforated with holes for that purpose, and between the glasses, in the direction of the arrows. In order to hold the inner glass b^1, a ring y with a sheet brass cylinder attached is introduced, which screws into r, this cylinder is pierced with holes and protected with a small copper gauze. The gauze b is attached to the ring x, and the chimney gauze v to the ring x^1, and in fitting up this portion of the lamp the gauze b and ring x are put in first, then the chimney v, then the glass cylinder b^1 with its washers, and, finally, the ring y, which presses the whole together.

The lamps are so constructed that this short glass and Davy gauze are interchangeable, and either the one or the other may be used as desired. The outside of the inner glass it is proposed to make a portion of a globe in order to obtain more light.

These lamps have, therefore, many advantages over other lamps: first, the ratio of safety is higher than any other known at present; and, second, if the glass is damaged the light is still guarded, in the No. 1 by a Davy gauze, and in No. 2 by the inner glass and gauze which form the inner lamp.

In both lamps complication has been avoided as far as possible, so that the cost of maintenance may be minimised.

In No. 1 the oil vessel will burn colza oil for 20 hours. The 24 feed air-holes, $\frac{1}{16}$ inch diameter, distribute the air around the entire centre of the lamp, which tends to keep the glass at a uniform temperature and comparatively cool, while at the same time it does not retain the coal-dust. The inside gauze, which comes from the bottom rim, can be withdrawn for examination as in the common Davy lamp. The outside gauze is covered with a sheet-brass bonnet, the whole being connected and supported by three standards or poles.

In the No. 2 lamp the oil vessel will burn a charge of colza oil 22 hours.

These lamps have been subjected to some months of work in the mine, being well liked by the men, and some hundreds of trials have been made with them in an experimental tester, with an explosive mixture ranging in velocity from 6 to 50 feet per second, and in no case have they been fired.

The following Tables give details of some of the experiments that have been tried, both as to the safety of the lamps and also as to their lighting powers.

EXPERIMENTS WITH ROUTLEDGE AND JOHNSON'S No. 1 SAFETY-LAMP.

ALDWARKE MAIN COLLIERY.

February 14th, March 1st and 10th, and May 10th, 1884.

Present—Members of the Midland Institute of Mining Engineers, and under the auspices of the same.

Velocity of Explosive Mixture. Feet per Second.	Remarks.
10½ ...	Went out entirely in 3 seconds.
10½ ...	Went out entirely in 3 seconds.
14 ...	Showed gas in 1 second, went out entirely in 5 seconds.
19 ...	Showed gas in 2 seconds, went out in 5 seconds.
19	(Placed in downward current) Showed gas in 1 second, went out in 2 seconds.
24 ...	Showed gas in 2 seconds, went out in 5 seconds more.
29 ...	Went out instantly.
29 ...	Went out in 4 seconds.
29 ...	Gas burned in lamp for 35 seconds, when supply was exhausted.
35 ...	Showed gas in 2 seconds, gas burned in gauze and re-lighted wick after 38 seconds.
40	(Flame unsteady) Gas burned in lamp, making gauze red hot, for 43 seconds. Supply exhausted.
40 ...	Gas burned inside of lamp for 55 seconds. Supply exhausted.
51 ...	Gas burned inside, making gauze red hot, for 35 seconds. Supply exhausted.

EXPERIMENTS WITH ROUTLEDGE AND JOHNSON'S No. 2 SAFETY-LAMP.

ALDWARKE MAIN COLLIERY.

February 26th, 1885.

Present—B. E. Dickenson, W. H. Routledge.

Velocity of Explosive Mixture. Feet per Second.	Remarks.
20 ...	Burnt inside for 5 seconds and then went out quietly.
20 ...	Went out in 3 seconds.
30 ...	Went out in 4 seconds.
40 ...	Burnt inside slightly but did not fire.
40 ...	Went out in 2 seconds very quietly.
40 ...	Went out in 30 seconds.
45 ...	Burnt slightly for 40 seconds till gas supply was exhausted.
50 ...	Burnt very quietly at neck of chimney till supply was exhausted.
50 ...	Lamp quite cool externally, no high temperature apparent in interior.
50 ...	Burnt slightly for 40 seconds till supply was exhausted.
50 ...	Wick flame much enlarged; slight blue flame observed at bottom of chimney near inlet.
50 ...	Wick flame extinguished; a very slight blue flame observed at bottom of chimney near inlet.

LIGHTING POWER OF THE ROUTLEDGE AND JOHNSON'S DOUBLE COMBINATION MINER'S SAFETY-LAMP.

EXPERIMENTS MADE FROM A 12 FEET STAFF, WITH PHOTOMETRIC APPARATUS, A SPERM CANDLE BEING USED AS THE STANDARD.

April 10th, 1885.

Lamp.	Equivalent in Lamps.	Percentage of Light.
Sperm Candle	...	... 100
Lamp with gauze inside of plain Clanny glass	5·27	... 19
Lamp with two plain Clanny glasses	1·35	... 74
Lamp with gauze inside of a magnified glass	2·77	... 36
Lamp with plain Clanny glass inside of magnified glass	1·10	... 91

In conclusion, it may be necessary to add that the foregoing statements with reference to the properties of these lamps are confirmed by the results, so far, of the actual use of them, and this gives the greatest confidence to the writer in bringing the lamps to the notice of members of the Institute.

The PRESIDENT said, they had heard Mr. Routledge's paper upon the very important subject of safety-lamps. This was rather a difficult subject to discuss, because many of those present had not seen the lamp, and a mere description of a lamp conveyed very little idea of its practical character. This lamp was introduced to their notice by a gentleman of practical experience. During the reading of the paper two points occurred to him. One was that Mr. Routledge mentioned that it was not very often that explosions were caused by gas issuing from a blower. He (the President) believed that at one of the Houghton pits where a borehole was bored into the old workings and gas came off with great pressure, the men left their lamps burning and ran out, and an explosion happened which must have taken place at the lamp itself from gas issuing with great force. Another way in which accidents might happen occurred within his own knowledge and experience. A master wasteman in passing over an air-crossing, through a very small aperture, in a very fiery condition of the air, stuck fast; he could get neither in or out. He pulled his lamp wick down with the wire but could not put it out. He was there for a considerable time in great danger, and the crossing ultimately had to be partially destroyed to get him out. They all knew that a Royal Commission on Mines was sitting, and it was hoped that Commission would arrive at some conclusion about lamps. The Commission had collected a great deal of information, and had made probably

more experiments than any other committee ever had, and it was hoped that the Commission would give the result in some practical form. The results of the Ellis Lever competition had not been satisfactory; a number of lamps were tested, but as none came up to the standard, no prize was given.

Mr. W. H. HEDLEY, referring to Mr. Routledge's statement that his lamp had never exploded when tested, asked if the lamp that had just been described was of the same description as the one which was tested at Aldwarke, before the Manchester Geological Society, about three weeks ago, and which it was stated had exploded in a current of gas 40 feet per second when exposed forty seconds to the test.

Mr. J. G. WEEKS wished to know whether any of these lamps had been submitted to the Royal Commission, and whether they took part in any competition for the reward offered by Mr. Ellis Lever (who had, however, taken care to make the conditions, under which the prize would be given, such as were impossible for any person to comply with.) He would also like to know if Mr. Routledge had made any photometric experiments as to the light given out by the lamps in comparison with that of the standard sperm candle, as this was a question of some importance.

Mr. ROUTLEDGE, in answer to these questions, stated that his lamps had been tested up to 50 feet per second, but he hardly thought that the lamp which he called the Official lamp would stand more than 40, but to whatever tests the lamp had been put in his presence there had never an explosion occurred, though he had not been present when all the experiments were made. In answer to Mr. Weeks he stated that there were four of the lamps at present before the Royal Commission. He had supplied the Secretary with an account of some experiments that had been made of the quantities of light given out by the various descriptions of lamp described in the paper. The Davy and Clanny combined lamp gives 18·975 or 19 per cent. of light, taking the standard sperm candle as 100. The one specially made for officials, of the same description, gives 36 per cent., while the Double Clanny gives 74 per cent., and when the outer glass of the latter is bulged outward it gives 91 per cent. of light.

The PRESIDENT proposed a vote of thanks to Mr. Routledge for the paper. He would like to mention a circumstance which occurred a short time ago. There was a discussion at the last meeting on the Marsaut lamp, and he stated that he had been informed, he did not speak of his own knowledge, that the lamp went out very readily in a current. He had since then had the opportunity of testing the lamp himself, and had

seen it tested under circumstances of very great difficulty, where the current was extremely strong, and, so far from it going out, he never saw a lamp which kept in so well. It was most remarkable the way the Marsaut lamp behaved itself in a strong current of air. He thought it only right to mention this after the remark he made on a previous occasion.

Mr. A. L. STEAVENSON seconded the vote of thanks, and said the Routledge-Johnson lamp seemed, in point of safety, everything desirable. As to weight, he thought it was rather heavy for ordinary use. He was very much bewildered at the present time as to which was the best lamp, as there were so many lamps by various makers, and it was difficult to say where the best was to be found. If this lamp had stood the test of 50 feet a second, nothing more in point of safety could be required.

The motion was agreed to.

The following paper was open for discussion:—"Notes on the Coal Fields and Coal Mining Operations in North Formosa," by Mr. David Tyzack.

Mr. Tyzack said, he had nothing to add to what he had stated in the paper.

The PRESIDENT—Has there not been quite recently some other paper read on the subject, or a publication by some Chinese Government officials about the coal-mines in Formosa?

Mr. TYZACK said, he was not aware of it. The various figures given in the paper were up to 1882, which was the time the Europeans left the mines, and after that time there was no European record. The mining was entirely in the hands of the Chinese now. There were several Chinese mining students when he was there, one of whom had been educated in France, and who took the management of the mines when he left.

The following papers were then announced to be open for discussion:—

"The Bilbao Iron Ore District," by Mr. B. J. Forrest.

"The Endless Chain in Spain," by Mr. George Lee.

The Secretary said, as the writers of both these papers were now in Spain, he did not know that any further information on the subjects could be obtained, but if any questions were asked he could correspond with the authors and perhaps get answers which might very much increase the value of the papers.

The meeting then concluded.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, JUNE 13TH, 1885, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

JOHN DAGLISH, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting and reported the Proceedings of the Council.

The balloting list for the annual election of officers in August, was submitted to the meeting in accordance with Rule 21.

The following gentlemen were elected, having been previously nominated :—

ASSOCIATE MEMBERS—

Mr. JOHN FORSTER LEE, Castle Eden Colliery, County Durham.

Mr. EDWARD HALSE, Assoc. R.S.M., Arenig Mines, Bala, North Wales.

STUDENT—

Mr. A. D. NICHOLSON, Mining Student, Eldon Colliery, County Durham.

Mr. W. J. BIRD read the following paper "On a New System of Coal-Getting, with Burnett's Patent Roller Mining Wedge and Nicking Machine :"—

ON A NEW SYSTEM OF COAL-GETTING, WITH BURNETT'S PATENT ROLLER MINING WEDGE AND NICKING MACHINE.

By W. J. BIRD.

Considerable attention has lately been directed to the introduction of appliances for coal-getting, to obviate the necessity for the use of gunpowder in coal-mines. On the one hand the use of lime cartridges, compressed air, and the like, have been suggested as alternative blasting agents; while on the other hand many attempts have been made to use mechanical wedges of various designs for breaking down coal. It is to one of the most recent of these latter inventions that the writer wishes to draw the attention of members of the Institute.

The tendency of modern legislation and of mine regulations affecting the work of coal-pits, is undoubtedly more and more towards restriction. The cause of many of the most disastrous of colliery explosions is alleged to be the use of gunpowder for blasting, when safety-lamps are used, and the probability of the prohibition of shot firing under such conditions in the not remote future may be contemplated.

A good mechanical wedge for breaking down coal should be so constructed as to exert a sufficient bursting pressure on the jud of coal to which it is applied, with an initial force that can be easily exerted by one man. To attain this object it is necessary that the friction produced by working the machine should be of the least possible amount. It is also desirable that the entire machine should be of such weight and dimensions as to be easily handled, whilst the working parts should be strong and not liable to get out of order.

A very important advantage that an efficient mechanical wedge gives, is the increase of the percentage of round coal in the output, and a consequent gain in the average selling price. Assuming an output to have an average selling price of 5s. per ton, and consisting of 50 per cent. round coal selling at 7s. per ton, and 50 per cent. of small, duff, &c.,

at the average of 3s. per ton, the following table will show how the average selling price of the whole output rises as the percentage of round increases:—

Percentage of round	...	50	55	60	65	70	75
Average selling price	...	5/-	5/2⅜	5/4¼	5/7⅛	5/9⅞	6/-

The use of gunpowder undoubtedly tends to shatter the cohesion of the coal, to diminish the percentage of round at the screens, and also, to a great degree, in transit and shipment.

The improved machine, as used at Wingate Colliery, is shown in Plate XXXVII., where it will be seen that the action of breaking down the coal is by drawing a wedge *a* between a series of rollers *b*, working against two feathers *c c*, which have been previously pushed into a hole bored into the coal about four inches in diameter. This wedge is a prolongation of a bar *d*, terminating in a screw *e*, which is sufficiently long to project some short distance clear of the hole. The feathers *c* are also prolonged by the rods *f* till they come outside the hole. These rods being riveted or otherwise secured to a short lever *g*, terminate in a projecting pin at *g'*. *h* is a nut working on the screw *e* and kept in its place by the washer *i*, made fast to the short lever *g* by four screws *j*. *k k* are the two sides of a ratchet-lever inclosing between its jaws the ratchet-wheel *k'*, and having attached to it a pawl *l* working on a pin *m*, and kept in its place by a spring *n*. The ratchet-wheel *k'* is screwed on to the nut *h* and made secure thereto, so that the nut will revolve with the ratchet-wheel. The sides of the ratchet-wheel *k k* are brought together and prolonged with an opening *o* cut in them. In this opening is introduced a short lever *p*, which works on the pin *g'*, and has a roller *q* working on pin *r*. The end of this short lever *p* is made square at *s*, and to this square is attached the lever *t*. *g'*, secured as it is by the two feathers *c*, which are jammed fast in the hole, is immovable, and as a backward and forward motion is given to the lever *t* the roller *p* communicates it to the ratchet brace with its curious-shaped opening *o*, which allows the brace to go just sufficiently backwards and forwards to catch one tooth of the ratchet-wheel, and no more, at every double stroke. The ratchet-wheel being attached to the nut *h*, acts on the screw *e* and pulls the wedge forward.

The gain of power in this wedge is such as to produce a bursting pressure of 5 tons for each pound force applied at the two-foot lever. In this wedge the screw is ⅝-inch pitch. It is proposed not to exceed ½-inch pitch, by which the power will be increased to 6 tons per pound applied.

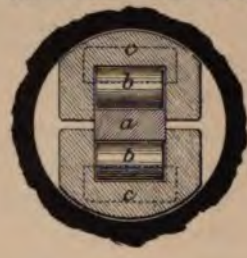
The improvements, which are themselves patented, in the "Improved" wedge are briefly as follows: First, guides for rollers are now formed on

1964

To illustrate Mr. W. J. Bird's paper "On a New system of Coal-getting,

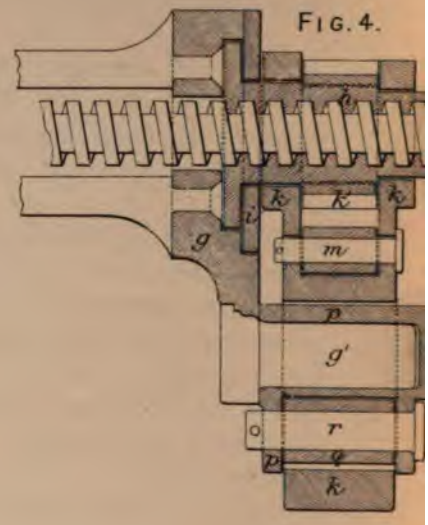
Scale ¼

FIG. 2.
SECTION THRO' A.B.



SECTION THRO' C.D.
FIG. 3.

FIG. 4.



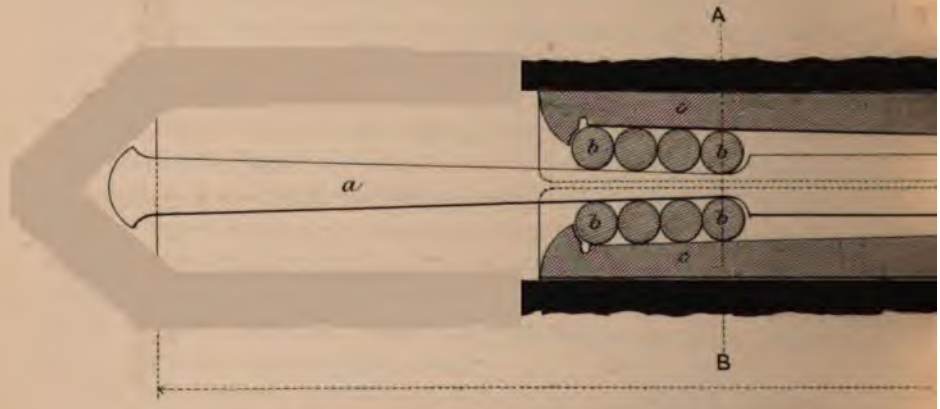


FIG. 8.

PLAN OF "NICKING

Proceedings N.E.I. of M.E. 1884-85

th Burnetts Patent Roller Mining Wedge, and Nicking Machine."

l size.

FIG. 5.

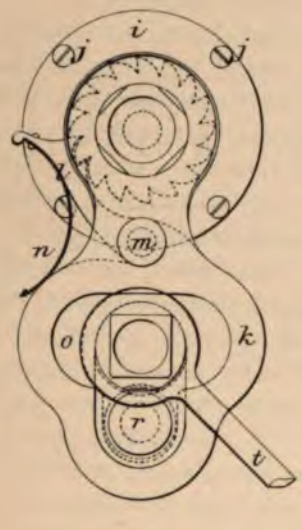


FIG. 6.

G. I.

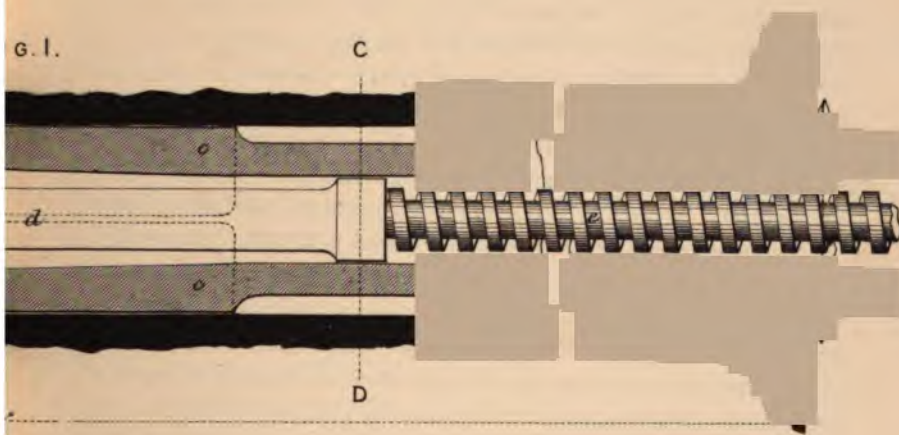


FIG. 7.

the feathers which are channelled for their reception, and are hence much stronger than in the original design, whilst, by the fact of the side plates being dispensed with, the simplicity of the machine is materially increased. Any number of rollers may be used, the one shown in the Plate has four on each side, thus distributing the pressure more equally. Second, the compound lever is improved, making the ratio of leverage more uniform. The new arrangement is also self-contained and is very easily worked.

The friction in working the "Improved" Roller Wedge is certainly much less than in any arrangement where wedges in sliding contact are used; in fact, the case may be compared to drawing a heavy load in a properly constructed carriage, as against dragging the same load along a surface in direct contact with it. It should be particularly noticed in the working of this wedge, that from the fact of the feathers being stationary, and the rollers in free contact with the wedge, the latter travels twice the distance of the rollers on the feathers.

The mode of working may now be briefly described. The place is first "kirved" to a depth of 3 feet. The wedge requires a hole to be drilled $4\frac{1}{4}$ inches diameter and 3 feet 6 inches in depth, out of which 2 feet 10 inches is taken up the full diameter, the wedge-bar projecting the remainder of the distance. It should be pointed out that this increased depth of 8 inches is not wasted, but is utilised for the next jud taken off. In places with two fast ends, both sides may be "nicked" to the same depth as the "kirving," and the hole drilled in the middle as near the top of the coal as possible; or the place may be nicked on one side only and the wedge hole drilled near the fast end. In cases where coal is kirved at the top, the wedge is of course applied at the bottom and exerts a lifting instead of a breaking down pressure. After introducing the wedge into its hole it is tightened into position by applying a suitable key to the nut h. Next, the handle l is placed on the supplementary lever p, which latter is provided with a roller q to diminish the friction, moving in a groove o in the ratchet-brace lever k. It will rarely be necessary to draw the wedge quite home. The jud soon begins to crack and it is desirable occasionally to intermit the process to give the coal time to work. When the jud falls it breaks off at the full depth of kirving, and the wedge falls down with it. The coal will usually come over in one large piece, which may break into several smaller pieces on striking the thill. Around the wedge-hole will be found a little small coal, the result of the crushing action of the wedge, the proportion of which will be less than 5 per cent. of the mass, all the rest being round coal.

It is also intended to use this wedge for stone, both in canches and

drifts. A wedge with a smaller taper is to be employed, and the dimensions decreased so as not to require a hole more than 3¼-inch diameter and 2 feet 6 inches deep. The reason why the taper is to be diminished is, that with the larger taper the bursting force is exerted at the interior end of the machine, which is what is required to break down a jud of coal back to the full depth of the kirving, but in taking down a stone canch, the pressure should be more evenly distributed, and consequently the taper should be decreased.

The wedge now described has just been tried at Wingate Colliery, in the Low Main Seam. In a bord 4 yards wide, a jud was kirved and nicked on both sides. The thickness of the seam is 3 feet 3 inches, and the coal is household, of a hard kind. The wedge hole was drilled in the middle of the jud and the wedge introduced; twelve minutes after the first application of the lever, the entire jud came down. Further trials are proceeding, the results of which the writer will lay before the members as early as possible.

In addition to the roller wedge, the patentee proposes to use a new method of nicking, Figs. 7 and 8, less laborious and tedious than the present hand nicking, and producing much less small coal. Previous suggestions for mechanical nicking seem to consist in cutting vertical grooves on each side of the place, a plan which may be well suited to the shattering action of powder, but in which the jud would be liable to jam under the steady action of the wedge. Mr. Burnett's proposition is to drill a hole, or a series of holes one above another, of say, 1½ or 2 inches in diameter, into the coal. Instead, however, of having either the groove or the holes in a vertical line it is intended to make them in a line at an angle slightly acute with the thill, say 5 degrees out of the perpendicular. By this means, when the pressure of the roller wedge is applied to the jud, it is intended that the coal should break along the line of holes, which being at this angle will allow the jud clearance to come down.

The principle of employing drill holes to determine lines of fracture has been in use in quarries for centuries, and the substitution of these drill holes at the above-mentioned angle, may reasonably be expected to be an economical advantage over the hand nicking hitherto in vogue. This system of mechanical nicking has been patented, and a nicking machine, for conveniently and expeditiously drilling these holes, will shortly be in working order when the writer hopes to be able to lay the results before this Institute. The proposed method is illustrated in the diagram.

SUPPLEMENTARY REMARKS.

The writer was present at the trials of the roller wedge subsequent to the completion of the paper. The following are the particulars thereof. Both trials were in the Low Main Seam, Wingate Colliery.

A bord, 5 yards wide, section of seam 3 feet 4 inches, was kirved across 3 feet 8 inches in, 1 foot 5 inches deep in front, nicked on both sides 3 feet in, tapering from 1 foot 4 inches to 7 inches. The wedge-hole was drilled in the middle of the jud. Fourteen minutes after the application of the lever, the whole jud came over in two large pieces. Only 8 inches, out of the 18 inches travel of the wedge, was utilised to effect this.

To test the power of the machine, it was next taken into a wall 4 yards 1 foot wide, kirved across 3 feet 4 inches in, not nicked, but quite fast at both ends. In drilling the hole for the reception of the wedge in the middle of the jud, the drilling apparatus broke down when the hole was only 2 feet 6 inches in, instead of 3 feet 6 inches. Notwithstanding this, the wedge was inserted as far as the depth of the hole would allow. After twenty-five minutes working the jud was brought down, with the exception of two pieces hanging in each nook, which were left in a loosened condition.

A machine for nicking in the new way proposed is not yet quite ready for experiments, but will be so in the course of a few days. It is anticipated that the nicking will be effected by the machine in considerably less time than it could be done in the ordinary way, with the advantage of an increased proportion of round coal got.

The patentee has submitted a specification of an improved machine for drilling, in which the use of a screw-bar is dispensed with, and one drill only used for the full depth bored. It may be worked continuously, and it is also adapted for the immediate withdrawal of the drills, which will greatly diminish the time occupied in the process. This improvement will be also applied to the nicking machine.

The combined system of the wedge and the nicking machine will be tried, by the permission of Mr. Armstrong, at Wingate Colliery, and by the time this paper comes on for discussion, the writer expects to be able to lay full details before the Institute; and he will willingly give any information, from time to time, of these trials to any member of the Institute interested in the subject.

The PRESIDENT said that this paper dealt with a question of very considerable interest at present. Several gentlemen, fortunately, were giving their attention to this subject, and they might hope, in the end, that something satisfactory would be produced. He proposed a vote of thanks to Mr. Bird, which was agreed to.

Mr. THEO. WOOD BUNNING then read the following "Account of the Experiments made in Germany by the Prussian Commission on Explosive Gas:"—

ACCOUNT OF THE EXPERIMENTS MADE AT THE KÖNIG COLLIERY AT NEUNKIRCHEN (SAARBRÜCKEN), PARTICULARLY THOSE ON THE CONSEQUENCES WHICH ARISE WHEN COAL-DUST AND GAS COME IN CONTACT WITH SHOTS; AND OTHER MATTERS INTIMATELY CONNECTED WITH THESE EXPERIMENTS.

UNDER THE DIRECTION OF THE PRUSSIAN COMMISSION ON EXPLOSIVE GAS; REPORTED ON BY HERRN HILT, OF AACHEN.

TRANSLATED BY THEO. WOOD BUNNING.

THE great uncertainty which remains as yet on the part which coal-dust plays in pit explosions, and especially with regard to the extraordinary views of the French writers, Mallard and Le Chatelier, in their exhaustive work upon this important question, caused the author of this memoir to issue a special petition, dated the 15th of December, 1883, which, after shortly stating the nature of the question, hinted that it was the province of the Prussian Commission on Gas to make experiments to set them at rest, and also pointed out the manner in which they should be carried out.

At the recommendation of the chairman of the Commission, Dr. Serlo, the Minister decided to carry out these experiments. The pit heap of the König Pit was chosen, as it seemed that a great many experiments would have to be made, and that pit gas would be necessary, and in this pit there was a powerful blower of natural gas which could be easily confined and brought to bank in pipes. The secretary to the Commission was then appointed to arrange the necessary erections and experiments; the actual carrying out of the latter in detail was, however, given to the Mines Inspector, Margraf.*

On the 9th June, 1884, the whole of the preparations were so far finished that the preliminary experiments could be commenced, and from the experience obtained from these the first programme for the ensuing months was arranged. After this first series of experiments was carried

* This gentleman was assisted during a portion of the time by the Mining Referendary, Herr Heinke; and afterwards, by the chemist, Dr. Brookmann.

out, a new programme was made on the 5th September, 1884, for additional ones; and on the 3rd and 4th October, 1884, the technical branch of the Gas Commission became acquainted with the nature and extent of the experiments, and enlarged the programme by another series.

At the end of 1884 the experiments had not yet come to a conclusion, and it seemed that several more months would be required to finish them especially as during that inclement season of the year they could not be carried out in the same continuous way as was possible when they were first commenced, but, nevertheless, the results already obtained are of sufficient importance to justify a preliminary report being made upon them.

It will be seen that the subject has been considered under four sections:—

1. General remarks respecting experiments with coal-dust and gas.
2. The arrangement of the experiments.
3. Description of the buildings in which they were made.
4. Results of the experiments.

(The two last instructions were prepared by the Inspector, Herr Margraf.)

Generally, it may be remarked, that the first division explains why the experiments were commenced and how they were really carried out, so that I have only here to draw attention to them. I will, however, remark that in all the experiments that have been at present made, the experimenters have contented themselves with sprinkling a thin coating of coal-dust over a certain defined length of the bottom of the gallery, so that about 1 lb. of dust was strewed over each foot in length; coal-dust was also used as a stemming for several shots. In many cases in the experimental trials, coal-dust was placed upon props and supports, which were fastened sideways in the gallery in order to imitate the props in the pit, but it was soon found out that this made very little difference, and it was determined, on account of its greater simplicity, to be content with comparative experiments when the coal-dust was sprinkled upon the bottom, especially as in pits it is more at the bottom than elsewhere. It must also be remarked that the shot stirs up and at the same time inflames the dust, and if, before, it was doubtful that this took place to anything like a serious extent, the very first experiments made it apparent that this was most decidedly the case, and that the coarse particles of dust with which several pits are strewed contained, nevertheless, a sufficient quantity of particles of coal-dust to fly about and become inflamed.

More especially referring to the principal points connected with the experiments—and particularly to those in divisions 2 and 4—it must be here remarked that the description of Inspector Margraf, notwithstanding its extreme detail, only gives a general picture of the large number of results obtained from these interesting experiments; later on it is intended to remark more fully on them when the record of the experiments, which at present contains upwards of 300, is published.

In the following remarks, I will endeavour to bring forward the most remarkable effects connected with the experiments, and to place before the reader, as clearly as possible, how far the present ideas respecting the action of coal-dust are confirmed or not, and point out the nature of the further experiments which remain to be carried out; and, in conclusion, make some passing remarks which the work already accomplished suggests.

The preliminary trials seem to have proved that clay stemmed shots,* with a charge of 8·11 ounces—whatever their direction may be with regard to the axis of the gallery—produce a length of flame between 9·84 and 13·12 feet, and also, to have shown that shots with 17·63 ounces of powder produced flames only slightly exceeding 13·12 feet (sparks arising from them did sometimes appear at a distance of 18 feet, but there was no distinct connecting flame); whilst these same holes stemmed with coal-dust, and without any strewing of coal-dust in the gallery, produced a length of flame between 29·5 and 52·5 feet with 8·11 ounces of powder, and one of 62·3 feet with 17·63 ounces of powder. The dust for these experiments was taken from the Hansa Pit, which contained only 16·2 per cent. of volatile matter, and belonged, as will be later explained, to that sort of dust which gives the average results. By later trials with the less gassy anthracite coal from the Worms district only, flames of from 26·2 to 29·5 feet long could be obtained when the holes were stemmed with coal-dust, and coal-dust was strewed along the gallery. It would, at all events, be advisable permanently to establish, by exhaustive experiments, how the various coal-dusts behave, and which of them usually give the most energetic results when coal-dust is used for stemming, without the strewing of coal in the gallery, in order in this way to establish at what length a blown-out shot can be dangerous when no coal-dust is within its range. It must also be considered that a shot which takes place in a hole bored in the coal has a certain destructive and distilling effect upon the sides of the hole. This effect, however, in no case causes a larger appearance of flame than that which is observed with coal-dust stemming.

* Soft, wet, ordinary clay.

The experiments upon the effect of a shot in a gallery in which coal-dust has been sprinkled, were arranged in such a way that one could compare the different shots with different sorts of dust, placed in the proportion of 1 lb. of dust to 1 foot in length, and using always the same quantity of 8·11 ounces of powder, first with clay and then with coal-dust stemming.

The results obtained by these experiments gave a sort of rule for the relative danger of the different kinds of dust, and even although the different circumstances connected with these experiments require in a certain way to be allowed for, yet the results have up to the present been of the greatest interest. Under these circumstances the length of the flame seems to vary between the maximum of 108·2 feet—which was reached when dust from the Pluto Pit was used, and the minimum of from 13 to 20 feet—which was arrived at when the dust from the anthracite coal from the Worms district, with clay stemming, was used. A very remarkable fact was observed, that when the easily-fired coal-dust was strewn for 33 feet along the gallery there was no perceptible difference whether the hole was stemmed with clay or with coal-dust, yet in the less easily inflamed gas the length of the flame was increased by the coal stemming from 6·5 to 23 feet.*

From this the following rule may be laid down: that when the length of flame is over 78·72 feet there is no perceptible difference whether the hole is stemmed with clay or coal dust, but that the difference is the greatest when the length of the flame, with clay stemming, is from 39·3 to 52·4 feet, in which case it is lengthened to from 62·3 to 72·16 feet; and when the length of the flame is under 39·4 feet, the effect of the coal stemming rapidly takes off.

It is very remarkable that so small a quantity as 33 lbs. of dust should have such a decided effect. Taking the cross section of the gallery at 17·5 square feet, the cubic contents of 33 feet will be 577 cubic feet, and 1 cubic yard of this space would contain about 1·5 lbs. of the 33 lbs. of coal which is strewn over the 33 feet, if it is admitted that the whole of the coal-dust is blown about. This is hardly possible, however, with most sorts of dust, which in a great measure are

* Compare this with the whole of the experiments which Herr Margraf refers to, and it will be seen that it does not give an accurate description of them, because it only gives the averages of many experiments. Here, for instance, the Pluto dust with clay stemming gave a flame of 101 feet, and with coal-dust of 108 feet; whereas the experiments themselves gave, with clay stemming 94 feet, and with coal stemming 110 feet. Small differences in the length of flame under similar circumstances cannot be avoided, because it is almost impossible to strew the dust exactly with the same equality.

composed of larger or smaller grains, and it is therefore, without doubt, unreasonable to suppose that the coal-dust is only dangerous when at least 1 lb. of dust is floating in 1 cubic yard of air. To fix the relationship between the dust and the space containing it with greater certainty will be the work of future experiments.

A simple calculation, however, will prove that a relatively very much smaller quantity is necessary in order to cause very energetic explosions.

The trials of Dr. Brookman seemed to show that the coke and coal-dust which remain after the explosion contain a very decidedly smaller percentage of volatile matter than the original coal that was strewn. The dust of the Pluto Pit was found to be as follows:—

	Trial 1. Per Cent.	Trial 2. Per Cent.
The strewn coal contained of volatile matter	22 ...	21·8
Volatile matter remaining in the coke after explosion	7·8 ...	13·6
Consequently the amount of volatile matter generated by the explosion was	14·2 ...	8·2

Taking the last figure, and presuming that the entire 33 lbs. which were strewn were volatilised to the same extent, there would be 2·7 lbs. of gas produced after the explosion. Consider, further, that according to the experiments of Dr. Brookman, coke remaining after the explosion contained almost as much O and N as the coal contained at first, so that the gases given out were almost entirely composed of H and CH^4, one can roughly assume that the above 2·7 lbs. would give about 70 cubic feet of gas at a temperature of 30° Fahrenheit, and at the atmospheric pressure; and this compared with the contents of the 33 feet of gallery, namely, 577 cubic feet, gives the proportion of about 12 per cent., which is more than is necessary to form the most dangerous gas mixture. When, however, it is considered that only a portion of the strewed coal gives up the whole of its volatile matter, it is clear that from these not altogether reliable calculations, phenomena can be produced sufficient to cause very powerful explosions, at all events when certain sorts of dust are used, and this is confirmed by the experiments.

Without doubt, the experiments prove that the coal-dust plays two distinct parts. In the first place, it becomes red-hot in a glowing stream of gas. It colours the yellow flame of the powder gas a dark red, and causes a perceptible lengthening of flame, because when the particles of coal once become glowing they remain so a long time. To this extent the coal-dust acts purely as dust, and no doubt similar effects might be obtained from the dust of other bodies, such as were found in the trials of Abel and others with magnesia powder. It would be exceedingly

desirable to test, by a number of experiments, the behaviour of a number of neutral bodies reduced to dust.

While it might be taken for granted that the phenomena which the anthracite coal-dust produces—namely, the lengthening of the flame from 9·8 to 19·6 feet, with clay stemming, and from 26·2 to 29·5 feet, with coal stemming—rest alone upon this mode of acting on the coal-dust, which, however, is not by any means clear, indeed not even probable, it is, nevertheless, without doubt proved that the very intense action of the other sorts of dust is produced by other circumstances, and can only be looked upon as being CAUSED BY THE BURNING OF THE GASES WHICH ARE DISTILLED OUT OF THE DUST DURING ITS HEATED STATE. This burning of the gas, however, can take place in two ways. First, by gradual distillation of the several particles of dust which are burnt as given out in a more or less active way, but which do not explode; and secondly, when a larger quantity of this gas is given out and mixed with a sufficient quantity of atmospheric air.

The observations made at present seem to prove that, as a rule, it is the first class of burning which happens, for in many cases when a flame, proceeding with an even velocity of about 3 feet per second, was observed, it often wavered up and down, and went back for a long distance and then again went forward. This last appearance was caused, probably, from the whole of the gas not being burned at once, either for want of oxygen or from the presence of gases not suitable for combustion, and only ultimately fired by the streaming towards it of fresh oxygen from the open safety-valves, in the same way as in a pit, oxygen would come in from side galleries.

Those appearances which were often observed show already the commencement of an explosion-like burning of the distilled products of the coal-dust, and similar appearances were regularly observed, with different sorts of dust, which the observer, Margraf, stated, were to be distinctly separated from those where the flame quietly passed along. The dust from the Pluto Pit, even when strewn only over 33 feet, once or twice produced A STRONG EXPLOSION WITH THE FLAME.

These phenomena, however, were very much increased when, instead of the dust being strewn only 33 feet along, it was strewn 65·6, 98·4, and 131·2 feet. The Pluto dust, which caused a strong explosion when strewn 33 feet and gave a flame 114·8 feet long, caused a heavy detonation when strewed 65·6 feet accompanied with dark red flames, a yard high, which streamed out of the safety-valve, and out of the opening close to the window, 18 *b*, which was 87·5 feet from the shot;

here a stream of fire about 20 inches long came out, which waved backwards and forwards, and the whole effect was that of an explosion. When the dust was strewed 98·4 feet, all these appearances were very much intensified, the flame passed 23 feet out of the end of the gallery which was 167·3 feet long, AND THERE WAS NO DOUBT THAT BY LENGTHENING THE STREWING OF THIS SORT OF DUST THE FLAME COULD BE PROLONGED TO ANY REQUIRED EXTENT.

It was the same when the dust from Neu-Iserlohn was used, this caused a heavy black afterdamp of a strong, tarry smell which it was impossible to breathe. The oxygen of the air was reduced to 16 and even less per cent. With regard to the amount of CO in the afterdamp, reliable data upon which conclusions may be based are entirely wanting. In the afterdamp which has been so far analysed it was not more than ·775 per cent.; this quantity, however, was only calculated from the supposition that in the afterdamp no unburnt CH^4 could exist, but it is exceedingly probable that the sample taken was not entirely free from air which, after the explosion, had come in from the safety-valve.

The length of the distance upon which the coal was strewn operated quite in a different way with other qualities of dust; for instance, that from the König Pit only gave a length of flame of 40 feet, no matter to what distance the gallery was strewn; but in this respect the experiments have not been carried out sufficiently to be exhaustive, and it will be necessary to try many more descriptions of dust, and sprinkle them over distances at least 100 feet long.

When one is asked why there is such a great difference in the results of the experiments with different dusts, it is not easy to give an answer from the experience obtained up to the present time; nevertheless, there are a number of important points which have been clearly elucidated, and those points which as yet have not been sufficiently explained can be easily filled up. First of all, it has been distinctly proved that the composition of the coal plays a very important part in the experiments, but by no means to such an extent as that it can be said that varieties of coal with less than from 20 to 16 per cent. of volatile matter are free from danger; their explosive power, however, may be said to be in proportion to the volatile matter contained in them, and is greatest in the coal which abounds most in gas, as was to be expected from the experiments of Galloway, Abel, Mallard, and Le Châtelier.

In order to make the experiments in regard to the quantity of volatile matter more easy to compare, the following table is given, where the experiments are registered in the order of the percentage of volatile

matter they contain, the average length of flame from the shot when 33 lbs. of dust was strewn over a length of 33 feet is given, the powder used was 8·11 oz., with clay stemming; the total loss of the volatile matter in the coke after the explosion, together with the quantity of O + N and H before the explosion and the loss of these in the coke afterwards, are also shown.

TABLE I.

The Pit from which the Coal-dust was taken.	Percentage of Volatile Matter.	Length of Flame.	Percentage Loss of Volatile Matter in the Coke after Explos'n	Percentage in the Coal-dust.		Percentage Loss in the Coke after the Explosion.	
				of O + N.	of H.	of O + N.	of H.
		Feet.					
1 Kohlscheid (Aix-la-Chapelle) ...	7·0	9·8	?	4·0	3·8	?	?
2 Morsbach „	8·0	13·1	?	4·5	4·2	?	?
3 Maria „	11·9	32·8	— 1·4	4·86	4·2	—0·05	—0·84
4 Eintracht Tiefbau (Westphalia)	15·5	59·0	— 8·0	5·62	4·45	—0·95	—1·38
5 Hansa „ ...	16·2	29·5	— 6·2	6·45	4·65	—1·43	—0·23
6 Siepen and Mühler „ ...	16·9	55·8	— 6·9	7·42	5·53	—1·82	—0·95
7 Obernkirchen (Hanover) ...	17·1	49·2	— 5·8	8·94	4·33	—2·06	—1·02
8 Gottesberg (Silesia)	17·7	29·5	?	6·78	3·91	+0·59	—0·67
9 Anna (Aix-la-Chapelle)	18·7	42·6	— 8·7	6·78	4·75	+0·48	—1·89
10 Hibernia (Westphalia)	20·2	65·6	— 3·7	7·52	4·98	+0·79	—1·06
11 Neu-Iserlohn „	20·5	68·9	—12·4	6·05	4·95	+0·43	—1·48
12 Pluto „	22·0	91·8	—14·8	7·25	4·88	—0·40	—1·60
13 Deutscher Kaiser (Westphalia)	27·0	42·6	— 7·0	9·94	5·09	—0·76	—0·67
14 Dudweiler (Saarbruck)	28·4	49·2	—11·6	11·25	5·62	—2·80	—1·44
15 Zollverein (Westphalia)	28·5	39·4	—10·0	11·62	5·14	—2·69	—0·78
16 Dahlsbusch „	28·7	39·4	—11·6	9·17	5·18	+0·43	—1·12
17 Rhein-Elbe „	30·2	55·8	— 9·4	9·08	6·13	—0·53	—0·67
18 Reden, Grubenwald (Saarbruck)	30·5	55·8	— 7·9	15·26	4·71	—3·36	—0·41
19 Friedenshoffnung (Silesia) ...	30·6	59·0	—17·6	8·91	5·44	+1·40	—1·68
20 Von der Heyat (Saarbruck) ...	30·7	39·4	— 4·2	15·45	4·44	+0·26	—0·30
21 Dechen „ ...	31·0	65·6	—10·6	13·20	5·66	—3·65	—1·57
22 Fuchsgrube (Schlesien)	32·5	23·0	—13·4	12·71	5·22	—2·83	—1·28
23 Maybach (Saarbruck)	32·6	32·8	—11·3	11·78	5·05	—1·60	—0·78
24 Reden, Kallenberg (Saarbruck)	35·8	42·6	— 9·8	19·04	4·93	—8·49	—0·54
25 Dudweiler „	35·2	52·5	— 9·8	11·69	5·33	—0·06	—0·85
26 Griesborn „	37·1	32·8	— 8·0	16·82	5·54	—1·42	—0·96

This table presents some very interesting facts; for instance that the length of flame, until a proportion of 22 per cent. of volatile constituents is reached, goes on increasing to some extent, if not altogether, proportionally with the quantity of volatile matter. The greatest exceptions to this were with the coal of the Hansa and Gottesberg pits, and the reason of this was, undoubtedly, that the dust was of exceedingly coarse quality, containing, sometimes, particles from ·118 to ·394 inches, and in many cases even ·788 to 1·57 inches in diameter. On the other side, when the dust contained more than 27 per cent. of volatile matter, there was a

very distinct falling off in the length of the flame, which in many cases was only the half of that caused by the coal having 22 per cent. of volatile particles. The higher percentage of volatile constituents did not produce any well-defined proportionate length of flame, and although many kinds of coal-dust gave a comparatively long length of flame, yet in no case did they give, even approximately, such a flame as the dust which contained 20 and 22 per cent of volatile particles.

Here it may be remarked that there is a want of experiments between dust containing from 22 to 27 per cent. of volatile matter.

It is not clearly enough explained how far the different results are to be traced to the different chemical compositions of the coal, and how far they are to be traced to the different fineness of the dust; indeed a great number of experiments prove that the fineness of the dust, which depends very much upon the composition of the coal, plays a very important part. Those sorts of coal having between 16 to 25 per cent. of volatile matter are not only very much the softest, but are also in many cases liable to disintegration in damp air producing a dust which is of its kind as fine as the finest flour. In a great number of cases the dust from Neu-Iserlohn, and particularly that from Pluto, have this property, and to this is attributed, in a great measure, the violence of the burnings and explosions which these dusts produced. It is also exceedingly probable that the other qualities of dust (especially its facility for parting with its volatile constituents when heated) play an important part.

So it will be found in the Journal that the coal-dust from the Deutscher Kaiser Pit was exceedingly fine and had been previously washed, yet, nevertheless, this very fine coal-dust with 27 per cent. of volatile particles only produced a flame of 40 feet.*

The table, however, distinctly shows that coal-dust with more than 27 per cent. of volatile particles in the average of cases only made a flame of about 40 or 50 feet; indeed the length of the flame produced from the Griesborn coal containing 37·1 per cent. of volatile constituents was only 32·8 feet, and that from the Fuchsgrube with 32·5 per cent. of volatile constituents was only 23·0 feet; but the dust from these pits was exceedingly coarse. On the other hand, other sorts of dust gave a length of flame of 55·8, 59·0 and even 65·6 feet, the last length, however, being

*It is well known by the experiment of Dr. Muck that it is not those coals that have the most gas that part with their volatile matters the soonest when warmed, which accounts for the fact that they give out less flame than those coals that contain from 20 to 23 per cent. of volatile matters.

only reached by the dust from the Dechen Pit (Saarbrücken) with 31 per cent. of volatile constituents, but this was described as particularly fine, having been gathered in the washing apparatus.

The same might be said also of the dust from Reden and Louisenthal, but these were made smaller by hand.

Respecting the effect of varied proportions of oxygen and hydrogen, no decided opinion can be formed, and still more experiments must be made in this direction. However, so much appears without doubt, that there is less loss of oxygen than of hydrogen in the coke after explosion; indeed in some cases there is absolutely an increase of oxygen. It appears that where there is a large quantity of oxygen—say from 8 to 9 per cent. as is the case in all gas coal—it shortens the flame. On the contrary, hydrogen, as soon as it has reached the proportion of 4·3 per cent., bears no distinct relation to the length of the flame.

The description of the trials which were made to ascertain the influence which the fineness of dust had upon the experiments gave most valuable information, which, however, cannot be said to be sufficient to justify the omission of further experiments, but they show that some coals which by themselves give no very particularly small dust, such as that from the Blücher seam in the König Pit, and which only cause an increased length of flame of from 19·7 to 23·0 feet when the shot is stemmed with clay, show 39·4 and 42·6 feet when the dust is passed through a sieve with from ·118 to ·157 inch openings, and that even the very large dust which will go through a sieve with openings of from ·788 to 1·18 inch is by no means free from danger, but will make flames 19·7 to 23·0 feet long, because there is with these larger particles, a certain quantity of very fine dust, and the experiments prove that only a VERY SMALL QUANTITY OF FINE DUST is necessary to bring about a state of things which should not be neglected; more experiments, however, are necessary to establish this clearly.

These experiments also prove that irrespective of the comparative length of flame there are also other circumstances connected with the mechanical effect produced during the experiments which call for remark. To measure these latter, an ordinary pit tub was placed outside, but with its back end in a line with the mouth of the gallery, on a railway rising from the gallery at an angle of four degrees, with a view to ascertain how far the explosion of the gas would drive it.

The figures given by the experimenter show clearly how the shock is increased by the fineness of the dust, and how very varied the shock is, under the same circumstances, with clay and coal stemming. Notably

these experiments show that the effect of the coal stemming is increased through the presence of fine dust.

Not less important than the before mentioned phenomena, which brought about the coal-dust alone, are those which occur when A CERTAIN KNOWN QUANTITY OF PIT GAS IS INTRODUCED. Experiments were therefore made to put beyond doubt how much the inflammability of the coal-dust is increased by introducing with it a small quantity of pit gas, if possible, to show clearly the mechanical effect, not only of the coal-dust alone, but also of coal-dust mixed with gas; but it will be necessary to obtain more precise information in this respect from the Journal of experiments attached to Margraf's report which, however, especially when describing the mode of experimenting, seems to leave nothing to be desired.

The influence of different quantities of gas well mixed with air upon the effect of shots was made clear by four series of experiments.

The first series gave the length of flame of a shot with clay stemming upon a mixture of 1 to 7 per cent. of pit gas and atmospheric air. The second, that of a shot with coal stemming under the same circumstances. The third was made in a gas mixture of from 1 to 6 per cent. with clay stemming, and with a sprinkling of coal dust of moderate quickness (Blücher seam, König Pit) over 33 feet of the length of the gallery; and by the fourth in the same mixture of gas with clay stemming, the thill being strewed with the very inflammable coal-dust from Neu-Iserlohn.

These two last experiments were especially interesting, because, besides the length of the flame, the mechanical work performed by the shots was also measured.

The following table gives these four sets of experiments.

EXPERIMENTS WITH 1 TO 7 PER CENT. OF GAS WITHOUT COAL STREWING.

Percentage of Gas.	Length of Flame with Clay Stemming.	Length of Flame Stemmed with dust from König Pit (Mehlpfuhl Seam).	Speed of Flame.
	Feet.	Feet.	
1·18	23·0	49·2	
2·36	31·16	49·2 62·3	One metre a second.
3·5	23·0	42·6 59·0	
4·7	44·6	70·5	
5·9	35·4	113·4	Very quick.
7·0	170·6	144·3	Like lightning.

EXPERIMENTS WITH 1 TO 6 PER CENT. OF GAS WITH COAL-DUST STREWN FOR 33 FEET ALONG THE THILL, THE SHOTS STEMMED WITH CLAY.

USING DUST FROM					
The Blucher Seam in the König Pit, which has passed through a sieve of 1 mm. opening.			New-Iserlohn (this dust was not so fine as that from the König Pit). The Length of Flame was not observed accurately.		
Percentage of Gas.	Length of Flame	The distance the Tub was blown along the Railway.	Speed of Flame.	Length of Flame.	The distance the Tub was blown along the Railway.
	Feet.	Feet.		Feet.	Feet.
0	49·2	2·29	One yard a second.	62·3	3·93
1	49·2	2·95		88·6	4·92
2	50·8	3·28		95·1	7·21
3	63·9	4·10	Like lightning	101·7	8·52
4	80·3	7·6	Explosion	118·1	11·1
5	114·8	10·8		150·9	23 to 32·8, Tub being much damaged.
6	134·5	45·9 19·7 with extra loading.			

It follows that when the ordinary clay stemmed shot which in the atmosphere produces a length of flame of from 9·8 to 13·1 feet, with even 1 per cent. of gas, produces a length of flame of 23·0 feet, while with a proportion of from 1 to 3·5 per cent. of gas the flame is between 23·0 and 29·5 feet, and with 3½ to 6 per cent. of gas it reaches from 36·0 to 42·6 feet, whereas with 7 per cent. an explosion occurs with a flame which reaches a length of 170·6 feet.

When the shot was stemmed with coal-dust from the König Pit, Mehlpfuhl seam, with 1 to 3½ per cent. of gas, the length of the flame reached 49 to 59 feet, and when the percentage was increased to 4·7 it reached a length of 70 feet, with 5·9 per cent. a result similar to an explosion was observed with a length of flame of 113·4 feet.

When the gallery was sprinkled with dust from the Blücher seam the length of flame with the clay stemmed shot was 49·2 feet long, and it was not much altered when 1 to 2 per cent. of gas was let in; but with 3 per cent. of gas the flame became 64 feet long, with 4 per cent. 80, with 5 per cent. 116·7, and with 6 per cent. 134·5 feet long. In the two last cases there were distinct signs of explosion accompanied with the characteristic double report.

All these appearances are greatly exaggerated when the gallery is strewn with the more volatile dust of Neu-Iserlohn; with 1 per cent. of gas, the length of the flame then reached 62 feet; with 2 per cent., 88 feet; and every further per cent. of gas it became a few feet longer. With 4 per cent. of gas even, there was a quickness of flame approaching to that of lightning, and with 5 per cent. an explosion with double report.

What, however, made these last experiments so especially interesting was the effect of the explosion upon the tub. With dust from the Blücher seam the table shews that while the tub, which with a clay stemmed shot with 33 feet of floor strewed with coal-dust was only pushed forward 2·9 feet, received a great additional impulse when 1 per cent of gas was admitted, which impulse was further increased with every fresh accession of gas, even when no increased length of flame was observed. With 4 per cent. of gas the tub was moved 6·25 feet; with 5 per cent., 11·5; and with 6 per cent., when the explosion occurred, more than 46 feet, and upon the repetition of the experiment a heavy laden tub was blown out 19·7 feet. The excessively energetic action of the dust from Neu-Iserlohn was very apparent. With 1 per cent. of gas the tub was moved less than 4 feet, which distance was only reached with Blücher dust with a mixture of 3 per cent. of gas. With 4 per cent. the Neu-Iserlohn dust drove the tub 8·53 feet. A slight explosion with 5 per cent. of gas drove the laden wagon 11·1 feet, a greater explosion with 6 per cent. drove it 32·8 feet, and when it was still more heavily laden it was driven 16·4 to 23 feet.

These experiments, however, must not be considered as conclusive. The inert dusts from Griesborn and Kohlscheid, have yet to be tried with small portions of gas; besides, experiments should be made with a longer strewing of those sorts of coal-dust, which, without gas, did not show any tendency to carry forward the flame beyond the usual length, by trying them with the percentage of from 2 to 3 per cent. of gas.

To this end some experiments have already been tried, but they are incomplete, and give such very contrary results, that it will be necessary to repeat them very carefully, with the assistance of the tub to measure the strength of the explosion.

It must be observed that the percentages given are those which were obtained by a calculation in which none of the little losses which occurred in obtaining and analysing the gas were taken into account; it was afterwards found that this calculation gave 10 per cent. more gas than that which the analyses gave when it was possible to make them with greater accuracy, so that a relatively higher proportion of CO was recorded, and it may well be said that all these results may be taken as the most harmless likely to happen with the given percentages of gas.

In every case, however, there can be no doubt that, as was stated by Galloway and Abel, though with their insufficient apparatus they could not prove it, that small quantities of pit gas strengthened the burning nature of the coal-dust, in spite of the decided contradiction of

Mallard and Le Châtelier. There can be no doubt that the mixtures here, were well, and seemingly regularly, diffused. This was found not only by the experiments recited by Dr. Margraf, but was confirmed and considerably strengthened by other results which were obtained when a quantity of pit gas, which, when well diffused, gave only 1·2 per cent. of the mixture, was allowed to come in and mix in various proportions with the air in the gallery, and the explosive portions fired by a shot or an electrical spark before the diffusion was effected; in this case gas explosions were caused, with all the characteristic appearances, which were totally different from the simple lengthening of the flame which took place when even higher percentages of gas were well mixed.

It requires to be particularly mentioned that when a very small quantity of the dust from the Pluto pit is used, its extraordinary qualities are apparent; when it is only strewed along a space of 33 feet, and with 2·1 per cent. of gas, the same appearances are obtained, which can only be arrived at with dust from the Neu-Iserlohn Pit with 4 per cent. of gas, and with König dust with 5 per cent.; and this shows that the effect of the dust is almost always more perceptible when the gas percentage is largest.

An experiment was made to place in comparison with each other, explosions caused by pure dust alone with those caused by gas, and it was found that with the dust from the Pluto Pit, when 132 lbs. were strewed over 132 feet, there was not only a regular explosion with a flame more than 164 feet long, exactly like that caused by a mixture of 7 per cent. of gas, equal to 50 cubic feet of gas put into a space of about 706 cubic feet, but that, in addition, the dust explosion blew the tub from 23·0 to 39·4 feet away from the mouth of the gallery.

Experiments with moistened coal-dust have not been made in sufficient number to merit any further description.

The experiments which Dr. Margraf tried, in order to prove the extension of an explosion between two separate accumulations of gas, by means of coal-dust, have, up to the present time, given no results (the side gallery not having been then completed); it may be remarked, however, that when the two accumulations of gas were placed in the gallery, the second portion, being placed between the first or exploded portion and the opening of the gallery, was pushed out before the inflamed coal-dust could come to it. A different result, however, was obtained when a trial was made in the sideway. It is true the firing of the gas which was in the side gallery did not always take place, but it did so in many cases, probably when easily inflamed coal-dust (for

instance, the Pluto dust) was strewn in the main gallery close up to the mouth of the side gallery, which was shut off from direct communication with the air by a stopping placed at its mouth, while the opening in the principal gallery was still free for the passage of the exploded gas. This arrangement, according to the description of the experiments given by Dr. Margraf, caused very severe explosions, first in the main gallery and then in the side gallery, which blew out the stopping at the mouth of the latter, causing bright flames to come out through every opening of both galleries, even through the freed opening at the mouth of the side one, followed by a thick afterdamp, which in a very short time filled the entire space round the galleries with a thick sooty substance. It is to be remarked, that in these experiments that portion of the principal gallery, in which the explosion originated, contained no mixture explosive in itself, but only a well distributed one of 5 per cent. of gas, so that the first explosion, as well as the propagation of it to the second mass, composed of 7 per cent. of gas, was caused only by the presence of the coal-dust.

From what has been said before, it seems that the experiments so far are not by any means complete, and it is not possible at present to arrive at any definite results, but certain important practical data can be given with safety, which may be summarised as follows:—

1.—The presence of coal-dust, such as exists more or less in the neighbourhood of places where shots are fired, will more or less extend the usual length of the flame resulting from a blown-out shot, to some extent in proportion to the greater or lesser quantity of pit gas which is found in the place.

2.—(*a*) When gas is not at all present the lengthening of the flame is limited, and for the most sorts of dust, does not exceed (regardless of the distance to which the coal-dust strewing extends), from 19·7 to 49·2 feet, at least when clay stemming has been used and the sides of the hole give out no gas with the explosion; when coal-dust is used for stemming, or the sides of the hole give out either fine coal-dust or gas, the flame may reach from 29·5 to 68·9 feet.

(*b*) There are, however, certain sorts of coal-dust which, when once inflamed by a shot, continue burning, and not only give appearances of flame over distances greatly exceeding those upon which the dust is strewed, BUT CAUSE ALSO REAL EXPLOSIONS WITHOUT THE PRESENCE OF THE LEAST QUANTITY OF GAS.

3.—(*a*) By the introduction of the smallest portion of gas all the appearances of burning become more intense, but with those sorts of dust which give the shortest amount of flame, a mixture of 3 per cent. of gas, only increases the length of the flame to a very small extent, and in no way causes it to extend along the entire length of the place over which the dust is strewed.

(*b*) When, however, the proportion of gas comes to 4 per cent. and upwards, these sorts of dust carry forth the flame to an indefinite extent, which otherwise is not the case.

(*c*) Those sorts of dust which, without gas, carry forth the flame to an indefinite extent, become distinctly explosive when mixed with a very small portion of gas, say, under 3 per cent.

4.—Separate collections of gas, in situations apart from each other, can be connected and fired by means of coal-dust, even when the first explosion is not caused by an explosive mixture of gas.

Notwithstanding it has often been stated, it may again be repeated that all the experiments described have been only caused by blown-out shots.

It has occurred that during the bursting of one of the cast-iron pipes the dust was not fired, and further more extended experiments will be made to ascertain if the dust will remain unfired under all similar conditions.

The presence of the coal-dust, however, is not by any means so dangerous as casual readers of these reports might suppose; and if absolute immunity from blown-out shots could be obtained, the dangers which are brought about by coal-dust would be almost entirely prevented.

Many people propose, for these reasons, to use stronger explosives than powder, such as dynamite, because with these, blown-out shots never occur. Without doubt, this proposition demands the most searching proof, but according to the account of experiments made with dynamite in the Maria-Anna Pit, near Bochum, by the manager, Mr. Menzel, no flame seems to come out from the hole when it is used, and the effect upon the coal, mechanically speaking, is not so unfavourable as might be thought, inasmuch as the coal is only broken to pieces to a very small extent in the vicinity of the shot, the largest quantity being merely shaken and brought down in large pieces.

It is necessary, in conclusion, to say how exceedingly valuable the Pieler spirit lamp was found to be as an indicator of gas; of course, this lamp was

never used to ascertain the percentage of gas—which was arrived at by measuring the amount let in by the gasometer—but it was used to find out whether the smaller quantities were properly and evenly diffused, which can be done quite easily with it. At the same time the opportunity was used to try the delicacy of this instrument as an indicator, and the results obtained in seven repeated experiments tallied so evenly that it was possible to construct the following scale:—With 1 per cent. of gas the flame came over the chimney 1·57 to 1·97 inches; with 2 per cent., 2·76 to 3·15 inches; with 3 per cent., 4·72 inches. From this it will be seen that every $\frac{1}{4}$ per cent. of gas caused the flame in the lamp to lengthen about ·4 inches, which is a considerable increase of size; and while it must be left for further experiments to obtain results below 1 per cent., and between 1 and 2 per cent., those given above may be considered as sufficiently approximate as far as they go.

The researches on the diffusion of the gas are not yet sufficient to enable a distinct opinion upon the subject to be given, and any further remarks had better be postponed till something more definite has been arrived at.

SECTION I.

GENERAL REMARKS RESPECTING EXPERIMENTS ON COAL-DUST.

After the general duties of the Commission were laid down, the nature of experiments upon the behaviour of coal-dust, which were to be undertaken, and the different modes by which these experiments should be carried on, were settled in the sixth sitting of the Commission, December 2nd, 1882.

In carrying out the resolutions taken in the last Commission of the 20th October of this year, I took upon me to make the following propositions:—

1.—That it was necessary to come to some definite opinion on the conclusion arrived at by Messrs. Mallard and Le Châtelier, which is given in the "Annales des Mines," Sér. 8, Vol. I., under the title of "The part Coal-dust plays in Accidents in Mines," which is entirely contrary to my convictions, for, whilst admitting the pains taken, and the thoroughness with which these experiments were carried out, I state most distinctly, that I do by no means entirely agree with the remark of the two authors, which is expressed in the conclusion of the article,

"we consider it, therefore, as proved that coal-dust, not accompanied with coal-gas, affords no serious danger, and can only play an important part when it increases the consequences of a gas explosion."

It would be easy to prove, out of the facts given by these gentlemen, that the part played by coal-dust is much larger and more devastating than this conclusion would seem to note; but it is not necessary to say more on the subject now, because there are many phases which have not been explained in a sufficiently clear manner, and any remarks which may have to be made would better come later, when more light has been obtained.

From the experiments which have already been made in different places, many facts seem to be brought forward with sufficient distinctness, but there is also much to be made more clear, so that it is possible that there may be a very marked difference between them and those which are yet to be tried. It is, therefore, better to arrange the following remarks in groups, and make short observations upon what is already proved and what remains further to be found out; and also what importance these experiments bear upon the special object in view.

A.—The following points are of extreme importance in considering the liability of coal-dust to become inflamed:—

1.—The composition of the coal-dust itself, that is to say, if it is

(*a*) More or less small;

(*b*) Whether it contains more or less volatile matter;

(*c*) Most probably, whether it contains more or less oxygen.

(*ad. a.*) In this respect it is proved that the finest dust is the most liable to be inflamed. It is to be remarked, however, that as the fineness of the dust depends in a great measure upon the ease with which the coal can be disintegrated, and, therefore, varies in the dust from the several pits, nevertheless, wherever dust in large masses is found, a certain quantity of it is always very fine dust, and this is the portion which first becomes suspended in the air and carries forward the flame. This will appear more prominently when, in a manner which will be later described, large quantities of special dust are taken from the pits direct, without being passed through a sieve before being experimented upon.

(*ad. b.*) The quantity of volatile matter is a very important factor in the case, and there are a great number of experiments made with negative results which show that many sorts of dust, on account of holding too small quantities of gas, could not be inflamed. The amount of this has not yet been determined; nevertheless, it

appears that coal, with less than 20 per cent. of volatile matter, is only dangerous under very unfavourable circumstances; that dust with 20 to 30 per cent. of volatile matter is more inflammable; and that such sorts of dust which approach or exceed 30 per cent. of volatile matter are very likely to be inflamed. The degree of danger from these sorts of dust, and the care which is necessitated by their presence, require to be specially determined.

(*ad. c.*) Whether, together with the quantity of gas in the coal-dust, the quantity of oxygen plays an important part, is not made clear in these experiments. This has been often admitted, and it is not by any means improbable, although it cannot be proved from the materials that are at hand, chiefly because, as a rule, the capacity for oxygen increases in a greater proportionate amount than the increase of volatile matter in the dust; and also because a careful chemical analysis of those coal-dusts which were most used was not made.

2.—The mode by which the dust was fired, that is, if—

(*a*) By a quietly burning flame;

(*b*) Whether it was caused by a sudden explosion of a lesser or greater amount of gas.

(*ad. a.*) It is incontestable that the size and impact of the flame has a very important influence. A quiet locally burning flame is very seldom, and with only a very few exceptions, capable of being carried a great distance by means of coal-dust, for this reason, dust in and by itself is not explosive.

(*ad. b.*) Therefore, only such explosions, as a rule, are dangerous which are caused by a sudden and great expansion of ignited gas, whether this gas comes from a blown-out shot, or from an explosion. In this case, even coal-dust, which is but little, or indeed not at all, subject to light up, at all events can be made hot and driven forward with violence by means of the heavy shocks which always accompany these movements of gas, then mixed with the air in the gallery and, in a red hot state, driven directly or indirectly, causing damage.

The experiments of Hall and Clark are intensely interesting; they show what an enormous difference in this respect there is between shots with a small and those with a heavy quantity of powder, and what a powerful effect shots from 2·2 lbs. to 2·54 lbs. of powder have had at great distances, when fired in a neighbourhood where dust is present.

3.—The quantity of gas in the surrounding air.

This point, which is without doubt the most important of all, is the one on which experimenters are the least in accord. While Galloway and Abel, with great positiveness, believe to have discovered by their experiments that a proportion of gas renders the firing of the dust very much easier, or, more properly speaking, that by the presence of coal-dust a percentage of gas, in itself harmless, will become either inflammable or explosive; and differ only with each other as to whether this result is obtained by 1·5 or with 2 or 3 per cent. of gas; Mallard and Le Châtelier deny this, not only because they rightly think the mode of conducting the experiments of Galloway and Abel were not sufficiently exact, but also because they themselves only obtained negative results. But the experiments of these last-named gentlemen do not appear either to have sufficiently covered the ground, nor to have been made in sufficient number to be worth quoting as a definite proof; and it should be one of the chief duties of the Commission now to clear up this most important question.

4.—Whether the gas mixture is stationary or moving?

At first sight this point seems to be a secondary one, or, perhaps, one of no importance whatever, because, it is said, that in still air no coal-dust can be suspended, therefore, the occurrence in question can only take place in moving air. But this view of things has already led to many useless and misleading experiments, and this is the reason why all the experiments upon the action of coal-dust in air mixed with 1 to 4 per cent. of gas have remained without any positive results, because endeavours were always made to produce them with the mixture pressing on in a moving stream, and it is very difficult, if not entirely impossible, to make such a stream of any known and regulated portion of gases. The results would have been entirely different if such a mixture had been let in and allowed to remain without motion, in sufficiently large spaces to enable a man with proper instruments to ascertain that the mixture was evenly diffused, and of the proper desired proportion; when in such a quiet mixture, a cloud of dust, and an explosion is caused artificially, as it can be in many ways, and probably the most easily by more or less heavily charged shots in the neighbourhood where the coal-dust had been placed, it would be quite possible to come to positive results.

B.—The principal danger to a mine from coal-dust can be divided into:—

1.—The direct danger of burning—

(*a*) From the coal-dust alone;

(*b*) From coal-dust increasing the chances of explosions from other causes.

2.—The deterioration of the air in the pit, which, in addition to the products of the perfect combustion of the coal-dust, would most likely have added to it the poisonous CO, attendant on its imperfect or partial combustion.

3.—Producing local explosions at long distances through carrying red-hot particles of coal-dust, and CAUSING OTHER EXPLOSIONS OF GAS MIXTURES IN OTHER PARTS OF THE PIT, WHICH MAY BE THUS RENDERED POSSIBLE (IN THE GOAF, FOR INSTANCE), WHICH, WITHOUT THE ASSISTANCE OF THE COAL-DUST, WOULD NOT HAVE BEEN REACHED BY THE SHOT OR THE FIRST EXPLOSION OF GAS.

(*ad. B.*) The before-mentioned consequences of the inflammability of coal-dust render it unnecessary to speak further of them here. As soon as the cause and appearances of the explosion are clearly set forth, the consequences which follow can be calculated theoretically, therefore further consideration of them is unnecessary; it is, however, desirable, where possible, that arrangements should be made that these consequences can be seen and observed by the experimenter.

After what has been said it becomes necessary, in order to carry out the experiments with sufficient exactness and without placing the experimenters in any danger, to have a gallery approaching, at all events, somewhat the general dimensions of a portion of a gallery of a mine, not shorter, certainly, than 164 feet, and one side at least of this gallery, and four-fifths of the other must rest in loose sand, with one end strongly closed up, and the other open to the air, this gallery to be so arranged internally that it can easily be separated into different sized compartments by means of doors. It is further necessary to have in the neighbourhood of both ends, large openings (used also as safety-valves) through which men could be admitted, that the entire length of the gallery should be provided with windows of very strong glass, protected with iron wire in the top part of the side walls, for the experimenters to look through.

Besides this, a gasometer will be necessary, the contents of which should be at least 176 cubic feet, with arrangements for filling it with pit gas and conducting the same at will into the closed end of the gallery. At

this closed end a large erection of stone should be arranged, containing different bore-holes, from which to fire off the shots with varied charges and stemming, by means of electricity, which would also necessitate an electrical installation. Indicators would also be wanted to detect the quantity of gas, together with tubs, &c., and, if possible, a small laboratory.

The only point which had to be more or less discussed was the mode of constructing the gallery. The use of an underground one already made was out of the question, as was also the use of a gallery made with sheet iron, on account of its cost and the difficulty of making windows and other necessary openings in sufficient number. The easiest way appeared to be to make the gallery of a number of wrought iron ellipses, which could be used again after the experiments were completed. These should be placed at distances of 2 feet, and clead in the inside with well tongued and fitted boards 2 inches thick, and partly covered by sand as before explained. This would make a most complete gallery, with the requisite resistance for carrying on any portion of the experiments without fear of injuring the experimenters.

This plan was adopted, and, during the whole of the important experiments on the effect of coal-dust, when shots were used there was no appearance of danger, probably to be accounted for because the holes from which the shots were fired were all in the direction of the length of the gallery and threw their fire along it; and no matter how the strength of the explosion was increased through the coal-dust the effect was principally in this direction and but slight upon the sides, so that the person recording the experiments was in no danger.

The experiments with the mixtures of gas will no doubt change these conditions, and the side walls will become strained; but it will be easy to guard against danger, for the first experiments can be made with very small mixtures of gas—about half per cent., and if these did not seem to offer any very considerable increase of danger, the percentage could be increased; also, tentative shots with smaller charges of powder, giving various developments of force (which did not involve any alterations of principle), could be used with the stronger quantities of gas until the safety of the sides was tested; thus it may be always possible to provide against dangerous consequences, and it will not be difficult for an intelligent experimenter to hit upon the right amount of risk to run, especially as it is not necessary to produce heavy explosions, but only to observe effects and to see how far they extend. If it should be found that the little glass windows were not sufficiently strong to bear the strain, they could be easily taken out and strengthened by

iron plates, and the distance the flame had gone could be ascertained by hanging some easily combustible bodies at different distances from the shot.

I will only further state that, in case it was considered necessary, a second gallery of shorter length, at right angles to the principal one, could be easily made.

HILT,
Mines Inspector.

Aachen,
15th December, 1883.

SECTION II.

THE MANAGEMENT OF THE EXPERIMENTS.

A.—PRELIMINARY EXPERIMENTS.

I.—The effect of ordinary shots with clay stemming. Eight experiments.

II.—The same with coal stemming. Eight experiments.

B.—PRINCIPAL EXPERIMENTS.

I.—Experiments to show the effect of the different holes with the same length of strewing of coal-dust, always taking the dust from the same pit, and renewing the dust after each trial.

(*a*) With clay stemming.

i. Seven different shots, with 8·11 ounces of powder.

ii. A shot out of the middle hole, with 17·63 ounces of powder.

(*b*) With coal stemming.

i. Seven different shots, with 8·11 ounces of powder.

ii. A shot out of the middle hole, with 17·63 ounces of powder.

II.—Experiments to determine the influence of strewing the same description of dust over 32·8, 65·6, 98·4, 131·2, and 164 feet of the gallery, the charge of powder remaining the same, and fired from the same hole, every experiment being made with fresh coal.

(*a*) With clay stemming, five shots.

(*b*) With coal stemming, five shots.

The shot hole used for these experiments is to be settled by the trials 1*a* and *b*, the one giving the most powerful effect is to be chosen.

III.—The continuous and complete trial of the different sorts of coal-dust in the district, arranged according to their sequence in the geological horizon; strewing them always the same distance, and repeating every trial.

(*a*) With clay stemming, fifty-four shots.

(*b*) With coal stemming with the same dust as that used for strewing in the gallery, fifty-four shots.

The coal-dust to be used to be taken from the following districts :—

(*α*) Silesia, Schaumburg, Westphalia, Aix-la-Chapelle, Saarbruck.

(*β*) Brown coal.

After every experiment three analyses are to be made—1st, of the coal-dust; 2nd, of the coke; 3rd, of the afterdamp.

IV.—Effect of the shots, with 1, 1½, 2, 2½, 3, 4, and 5 per cent. of gas, perfectly diffused, without coal being strewed.

(*a*) With clay stemming, seven shots.

(*b*) With coal stemming, seven shots.

With every trial of gas at the commencement of each experiment, and every time the gasometer is filled, samples are to be taken for analysis.

V.—Experiments in relation to the explosion of gas not perfectly mixed, by means of the direct electrical spark, at different levels, namely :—1·64, 1·98, 2·3, 2·62, 2·95, 3·3, 3·61, 3·93 feet high, reckoned from the bottom, and in different degrees of mixture, beginning with ·02, ·025, ·03, ·035, ·04, ·045, ·05 per cent.; 56 trials.

The proportions of the mixture to be made by calculation.

VI.—Experiments in relation to the explosion of gas perfectly diffused, with coal strewing, the holes stemmed with coal-dust taken from that used for strewing the bottom.

(*a*) In space 1.

(*b*) In spaces 1 and 2.

(*c*) Beyond space 2.

With 1, 2, 2½, 3, 3½, 4, 4½, and 5 per cent. of gas; 24 experiments.

VII.—Experiments in order to come to some conclusion respecting the carrying-forward of an explosion, between two places at some distance apart, containing explosive gas mixtures, through the instrumentality of coal-dust alone.

Neunkirchen, 14th July, 1884.

FIRST SUPPLEMENTARY PROGRAMME FOR THE COAL-DUST EXPERIMENTS.

A.—Two sets of check experiments with coal-dust (*a*, from the König Pit, and *b*, from Neu-Iserlohn), with accurately measured quantities of from 1 to 6 per cent. of gas, well diffused. These experiments should be made in duplicate, especially for mixtures between 1 and 3 per cent., and the shots be stemmed only with clay.

B.—A series of experiments with the same coal-dust without gas, with ever-increasing size of dust, by passing it through sieves of ·04, ·12, ·24, ·40, ·59, ·79, and 1·18 inch openings.

C.—Experiments on the diffusion of gas in atmospheric air.

(*a*) Certain quantities, varying in proportion from 2 to 3, 4 and 5 per cent., are to be allowed to stream into the gallery, and tried at intervals of at least two hours to see how the diffusion had taken place without being assisted by artificial means. When this seems to have been perfectly effected, samples to be taken from the top and bottom of the gallery.

(*b*) As soon as an equally diffused mixture of the required quantity of gas is formed, it is to be allowed to stand some time quiet, and after an interval of not less than twenty-four hours, the uniformity of the diffusion is to be tried. At the beginning, as well as at the end of these trials, samples are to be taken from the top as well as from the bottom of the gallery. These trials are to be made as well with 2 to 3 as 5 to 6 per cent. of mixture.

D.—In case the gallery which is placed at right angles is used, two other series of experiments are to be made, besides the experiments indicated under head VII. of the principal programme, the one with the sprinkling carried into the side gallery, and the second without. For all the experiments in the side gallery this latter will have to be shut up at the opening to the atmosphere, but not so securely as the principal gallery which is enclosed with brickwork.

Neunkirchen, Sept. 5th, 1884.

SECTION III.

DESCRIPTION OF THE BUILDINGS IN WHICH THE EXPERIMENTS WERE MADE.

The design for the building of the apparatus was made to carry out conditions which would approximate as nearly as possible those which were usually present in pits; the structure was, therefore, an imitation of

an underground pit, and consisted of a gallery 167·3 feet long, made of elliptical rings of H iron, clead inside with fir planks 2 inches thick. (See Plate XXXVIII., Figs. 1, 2, 3, and 4.) The planks were planed smooth all over, and the edges made to come close together, besides which, throughout their length, they were further secured by tongue and feather. The height is 5·64 feet, and the breadth, 3·936 feet, having a cross section of 17·5 square feet. At one end is a block of building made of stone, 12·3 feet long, 9·8 feet broad, and 13·1 feet high, allowing the gallery to enter into it 3·8 feet.

This block of building, which stands on a platform 1·6 feet high, represents the place in which the shots are fired ; and for that purpose seven pieces of cast-iron tubes, the inside arrangements of which were made to represent ordinary bore-holes, were built in such a way that two of them were close to the top, three in the middle, and two near the bottom (Fig. 4); the axes of those which are near the top and those which are near the bottom are so arranged that when produced they form a four sided pyramid, the point of which is exactly in the middle of the gallery, 16·4 feet distant from the holes, so that when the axes are produced to a distance of 32·8 feet from the bore-holes they strike both the top and the bottom of the gallery. The axes of the holes in the middle are so arranged that the fire coming from them meets at a point 16·4 feet distant from the masonry in the middle of the gallery. The bore-holes are numbered, and with the exception of the middle one, have a diameter of 1·38 inches, and a depth of 31·52 inches, whereas the middle one is 37·1 inches deep, and has a diameter of 1·57 inches. The whole of the tubes are proved before they are set in the wall, by firing them off many times with stemmed clay, with a charge of 17·63 ounces of powder in No. 4 tube, and 8·8 ounces in the others.

In order to take off the kick of the tube against the brickwork a number of small pieces of soft wood were inserted, between which were placed circles of india-rubber. The masonry was secured by eight anchors, in order to give it the greatest possible amount of security. And here it is to be remarked that in spite of the large quantity of powder—amounting to nearly 2 cwt.—which, little by little, was shot away, there was not the smallest split in the masonry observable, and the tubes remained unshaken in their places.

The entire gallery was buried in a disused pit heap, on one side up to its roof, and on the other side about three-quarters up. On the side which was left free 32 windows were made, somewhat more than a yard apart, which were glazed with panes ·79 inches thick, fixed in cast-iron frames ;

5·5 feet from the bore-holes there is an oval opening, like a man-hole, in the roof of the gallery, which serves first for its ventilation, secondly to allow the introduction of the stemming material, and also as a second entrance in order to avoid having to walk round by the mouth of the gallery. During the experiments, this opening was shut with a door in the same way as is usual with man-holes.

Also, at 7·54 feet, 16·0 feet, and 28·5 feet from the bore-holes, openings of 7·9 inches diameter were made in the top of the gallery which were shut during the experiments by loose clumps of wood fastened by chains. At every shot these fly in the air and act as safety-valves to the gallery. The opening, which was placed 88·6 feet from the face of shots, was for the purpose of enabling the gallery to be quickly cleared of afterdamp, and for this purpose a Körting's Exhauster, driven with compressed air, was inserted, and in the latter experiments one of the openings of the safety-valves was used so that the afterdamp could be cleared away in two distinct places.

Here it is to be remarked that in spite of all these arrangements it always took from twenty to twenty-five minutes to empty the gallery of after-damp.

In the inside, 40·3 feet from the face of the shot-hole, there was a wooden frame, by means of which a space containing exactly 706 cubic feet could be shut off, and this was arranged so that sail-cloth could be stretched across and fastened to the wood. The chamber thus arranged was for the purpose of receiving the gas with which the experiments were to be made, and the sail-cloth, in order to enable communication to be made from the outside, was only nailed down so far that the under end could be lifted up to enable the experimenter to get inside. Further along the gallery five more such frames were placed, which were, however, only used in the way just mentioned to oppose greater resistance to the escape of the gas.

In this space and 16·4 feet further on, the joints of the boarding which clead the gallery were made tight with red lead, and in order, as far as possible, to insure the structure against fire, it was from time to time covered with a thick mixture of whitewash.

There was also in the neighbourhood of the gallery a water-hydrant, so that any fire which might accidentally break out could be speedily extinguished.

The gas that was used in the experiments came from a blower in the bottom of the No. 1 deep workings in the König Pit, 393·6 feet below daylight, in the roof of the seam Grolmann, from a cross-grained

conglomorate which has for years given off ·88 cubic feet of gas per minute. This gas was conducted by means of a tube 3,608 feet long, to a gasometer at bank, holding 176·5 cubic feet, and from this it was carried into the previously described chamber as it was wanted. The requisite opening to admit the gas was 4 feet from the shots and 1·64 feet above the bottom of the gallery. The rising and falling of the gasometer was read by a gauge divided into ·236 inches. Forty to forty-five minutes were necessary in order to pass 35·3 feet of gas. When the gasometer was filled the pipe was shut and the gas allowed to flow out by the side of the gasometer into an upright pipe, 6·58 feet high and ·788 inches diameter, in the open air. When the gas was lighted at the end of this tube a yellow flame came out 18 inches high.

The Abegg's detonator was used, with an electrical machine by Mahler and Eschenbacher. The latter was placed in one of the casements which was placed by the side of the gallery for the safety of the observers. The observations were carried on through loopholes which were opposite the windows in the gallery.

A side gallery has been added quite lately, 32·8 feet long, shown in the Plate, and made in the same way as the first gallery, the mouth of which can be secured by a door provided with a safety-valve. This was put up for the purpose of observing the effect of burning coal-dust upon accumulations of gas placed by the side of the principal gallery.

Lastly, a small railway was laid at the end of the gallery, rising upwards with a gradient of 4 per cent. Here was placed an ordinary pit-tub, so that the force of the explosion could be measured.

MARGRAF.

SECTION IV.

RESULTS OF THE EXPERIMENTS.

The experiments were carried out in the terms of the first programme arranged 14th June, 1884, and under the additional programme of 5th September, 1884. The last programme provided not only for the repetition of several of the experiments named in the first programme, but required two sets of experiments which were suggested by the results of previous observations, and which opened out quite a new field. Bearing this in mind, therefore, the results following both the first and additional programmes, which are, to some extent, connected with each other, will be spoken of together.

A.—PRELIMINARY EXPERIMENTS.

The effect of ordinary shots with clay and coal-dust stemming respectively.—These preliminary experiments were made in order to fix the length of flame of an ordinary shot made with 12-inch cartridges, such as are usually used in the König Pit, which have an outer diameter of 1·30 inches, and an average length of 11·8 inches, with a weight of powder of 8·8 ounces. These could be used for all the shot-holes, with the exception of the middle one, and allowed of a length of stemming of 19·5 inches. With regard to the stemming, it is to be remarked that in all the experiments, in order to avoid bursting the tubes, it was not driven tightly home but only gently pressed down by a wooden rammer in the same manner as when stemming with dynamite.

The length of the flame of an ordinary shot with clay stemming was from 9·8 to 13·1 feet; and in order to find out if the length of the stemming had any influence over the length of the flame, two experiments were made with stemming of 1·57 inches, with the same result. The colour of the flame was a light yellow.

The shot out of the middle bore-hole, made with 17·62 ounces of powder, 16·9-inch length of cartridge, and 20-inch length of stemming caused also a flame of only 13·1 feet long. Stemming with very fine coal-dust taken from the Hansa Pit in Westphalia, and from the Dechen Pit, near Saarbruck, respectively, caused the length of flame to vary between 29·5 and 52·5 feet, and with a shot out of the middle hole with 17·62 ounces of powder, produced a length of 62·3 feet; the colour of the flame being dark red.

The number of clay and coal-dust stemmed shots were 10 and 12 respectively.

B.—PRINCIPAL EXPERIMENTS.

Trials to establish the working of different bore-holes on similar sprinklings of coal-dust taken from one and the same pit.—These experiments were made with a view to establish the working of the different bore-holes with a strewing of coal-dust from the same pit and of similar length, namely, 33 feet. This sprinkling was done in such a way that in the middle of the bottom of the gallery it was of the thickness of three-quarters of an inch, whilst at each side, in consequence of the hollow form of the thill, it became less.

The dust so strewed had an average weight of 33 lbs., and was in the proportion of 17·43 cubic feet of gallery space to 1 lb. of dust.

The experiments were made with clay and also with coal-dust stemming and the coal-dust used then, and in all further experiments, was always taken from the same dust as the dust used in strewing, the dust strewed being renewed after every experiment. Immediately before the shot was fired the coal-dust was placed in such a state of circulation that the air was thickly and evenly impregnated with it. The time which elapsed between the finishing of the strewing and the firing of the shot was usually four or, at the most, five minutes.

The holes were always charged with the before-mentioned 12-inch cartridges, unless distinctly stated to the contrary.

By the experiments with clay stemming it was ascertained that the shots that were nearest the bottom, that is, the holes Nos. 6 and 7, although their axes were directed upwards, made the longest flames. These reached from 59 to 63 feet long, while those of the upper holes were only from 9·8 to 26·2 feet long. It is supposed that the greater effect of the first holes was caused by the greater commotion made in the dust at the bottom. One shot of 17·63 ounces of powder, out of No. 4 hole, produced a flame of 72·2 feet.

The dust used for the sprinkling was fine, and came from the Hansa Pit in Westphalia.

By these experiments the flame in the vicinity of the shot-holes, at the moment of the explosion, was observed to have a yellow colour, but in the next moment to become an intensely dark red; an appearance which was observed in all of the experiments with clay stemming and coal-dust strewing.

By this and many of the later experiments made upon coal-dust strewing (as already mentioned in the preliminary experiments with coal stemming) an appearance was produced in the first windows of the gallery, at a length of about 8·52 feet from the shot-holes, after the first flame had gone past, as if a second flame appeared, generally with a sharply defined, oft repeated, up and down, side motion, like a flame driven hither and thither. The colour of this flame was always dark red, and the appearance remained for two or three seconds. In certain cases it was also remarked that the chief flame, when it had reached its greatest length, stood still for one or two seconds, and then came several feet slowly back. To all appearances the circumstance was due to the flowing in of fresh atmospheric air through the open end of the gallery and through the safety-valve, caused by the rarefication of the air after the explosion, which again set fire to the coal-dust.

In the further experiments upon the working of the several bore-holes with coal-dust stemming, fine dust from the Beust seam, of the Saarbruck Pit, Gerhard (Louisenthal), was used. These experiments produced, from Nos. 6 and 7 holes, flames of lengths varying from 78·7 to 95·1 feet. These lengths, however, were not confined to the above-named holes, for the same length of flame was obtained from the holes 4 and 5. The flames from the shots of 1, 2, and 3, were from 72·2 to 75·4 feet long. These experiments also show that the difference in the effect between the several holes was not so great with coal stemming as when they were stemmed with clay. It is, nevertheless, more proper to consider the latter, that is, the lower holes, to be those which denote the rule, and which really give the most reliable results; in fact, all the experiments from which the most pronounced effects were produced, were those which were made from the lower holes, Nos. 6 and 7, with dust strewing. The colour of the flame was always, in these experiments, as in all later ones under the same circumstances, dark red. The coke and the after-damp will be afterwards spoken of.

Experiments to determine the influence of strewing the same description of dust for different lengths.—The second part of these first experiments was to find out the influence produced by different modes of strewing the dust, and by the different lengths over which the same description of dust was strewed: they were made with dust from the König Pit, near Saarbruck, Pluto, and Neu-Iserlohn (Westphalia), and the shots were fired from one of the lower holes, usually No. 6, with coal-dust stemming. The sprinkling was renewed after every shot.

While, when the coal-dust from the König Pit was used over lengths of 32·8, 65·6, and 98·4 feet the flame was almost always from 36·1 to 39·4 feet long, and was uniformly longer when the Pluto and Neu-Iserlohn dust was sprinkled for greater distances. So that, with dust strewed for a distance of 131·2 feet, flames of from 16·4 to 23·0 feet came out at the opening of the gallery; that is, the flames must have been at least from 183·7 to 190·2 feet long. At the same time, when the strewing was 65·6 feet long, heavy detonations took place, sending dark red flames, 6 feet high, out of the openings and safety-valves with great force, and producing a thick, heavy after-damp, smelling strongly of tar, which darkened for some minutes the whole space round about the gallery, as though a very heavy explosion had taken place.

In accounting for these very varied results it may be remarked that

the difference between the dust from the Pluto and Neu-Iserlohn Pits and the dust from the König Pit was, that the former was very fine and more like meal, whereas the latter had been passed through a sieve of ·275 inch holes and had amongst it particles rather larger than the size of peas.

Influence of the different sizes of dust.—These experiments were made to determine the influence which the size of the dust had upon the result of the experiments, in accordance with the additional programme, and were made with the dust from the König Pit, sieved through ·04, ·12, ·24, ·39, ·59, and 1·18 inch holes.

The different sorts of dust were strewed about 33 feet long, and No. 6 bore-hole was used.

a. CLAY STEMMING.

Size of Sieve Openings. Inches.		Length of Flame. Feet.
·04	...	49·2
·12	...	45·9
·24	...	29·5
·39	...	29·5
·59	...	29·5
·79	...	29·5
1·18	...	26·2

b. COAL STEMMING.

Size of Sieve Openings. Inches.		Length of Flame. Feet.
·04	...	62·3
·12	...	59·0
·24	...	39·4
·39	...	39·4
·59	...	39·4
·79	...	45·9
1·18	...	36·1

These experiments show that with the two sorts of stemming there was a very important difference in the length of the flame when the size of the dust exceeded ·12 inch, and this size once attained, the length of flame remained about the same all through the experiments, even when the largest dust was used.

It is true these results will not apply to all sorts of dust, for with a soft coal the quantity of the finest dust which will pass through a sieve of, say ·12 inch openings, will be much greater than would be the quantity coming from a harder coal, so that the same length of strewing would give an unequal quantity of the finest dust.

In conclusion, and particularly with regard to the comparison between the König dust on the one side, and the Pluto dust, as well as the Neu-Iserlohn dust, on the other side, there is yet to be said that when the dust is passed through a sieve with ·04 inch holes, the result obtained from the König dust is not nearly so fine as that obtained from the Pluto and Neu-Iserlohn dusts; for the König dust does not ball itself between the ends of the fingers, and is more gritty to the touch than that of the two last sorts.

Experiments relating to the firing of coal-dust, when the strewing does not commence directly from the place where the shots are fired.—A few experiments were made with dust from the König Pit, passed through a ·27 in. spaced sieve, to ascertain the length of flame with coal stemming when the strewing commenced at distances of 16·4, 24·6 and 32·8 feet from the place where the shot was fired, and these experiments gave only the usual length of flame due to this mode of stemming. It is in contemplation to continue these experiments with the Pluto and Neu-Iserlohn dusts.

Continued experiments with different sorts of dust taken from several districts.—These were mostly tried from Nos. 6 and 7 holes, with 33 feet of strewing, as well with clay as with coal-dust stemming. Each of the experiments, when sufficient coal-dust was available, was tried at least twice, and where the observed results differed very much from each other it was repeated four or five times. The results of these trials are given in the table on the following page, which shows also the length of the flames, and the quantity of the volatile matter in the coal-dust and in the coke produced after the explosion. The latter results are given in averages, and reckoned without taking water and ash into consideration.

It will be seen from the table that the flames from the dusts last tabulated did not differ very much in length when the hole was stemmed with clay or when it was stemmed with coal-dust. They are alike for the dusts of the Hibernia and Neu-Iserlohn Pits, and for the dusts of Rhein-Elbe, Pluto, the Union Company's Pits at Kohlscheid, Dudweiler, Von der Heydt, Reden, and Dechen they are very nearly alike, while the difference between the others, with the exception of the Fuchs Pit, is only from 9·8 to 23·0 feet.

This exception, however, gave a difference of length of 42·6 feet, which result was substantiated by many experiments, and can be explained by the fact that the dust was mostly a very coarse powder, only mixed with a very small quantity of fine coal particles. This latter, which, when shaken up by the shot, forms the upper part of the mixture, was not, in itself, in sufficient quantity to affect the flame, especially when clay stemming was used, so that from the two shots a very slight increase over the ordinary length of flame was observed.

No conclusion can be founded upon the effect of the shot on the very fine dust from the Fuchs Pit, unless the experiment with the coal stemmed shot can be said to afford one. By the above experiments the

NAME OF PIT.	Clay Stemming.				Coal-Dust Stemming.			
	Length of Flame.	Amount of Volatile Matter.		Amount of Volatile Matter lost by the Dust.	Length of Flame.	Amount of Volatile Matter.		Amount of Volatile Matter lost by the Dust.
		In the Dust.	In the Coke Formd			In the Dust.	In the Coke Formd	
	Feet.	Per Cent.	Per Cent.		Feet.	Per Cent.	Per Cent.	
A.—Silesia.								
Fuchs Pit, Wiessstein, very large dust	23·0	32·5	No coke found.		65·6	32·5	22·3	10·2
Karl Georg Victor, Gottesberg, medium sized dust	39·4	19·7	14·1	5·6	55·7	19·7	12·9	6·8
Friedenshoffnung, Waldenburg, fine dust	68·9	30·6	19·0	11·6	78·7	30·6	15·4	15·2
B.—Schaumburg.								
From the pits in the mining district of Oberukirchen, fine dust	59·0	17·1	No analysis.		72·2	17·1	11·8	5·3
C.—Westphalia.								
Rhein-Elbe, fine dust	65·6	30·2	No analysis.		72·2	30·2	20·8	9·4
Hibernia, very fine	75·4	20·2	15·8	4·4	75·4	20·2	16·5	3·7
Dahlsbusch, medium	49·2	28·7	No analysis.		65·6	28·7	17·1	11·6
Zollverein, do.	49·2	28·5	18·5	10·5	72·2	28·5	No analysis.	
Hansa, very coarse	39·4	16·2	No analysis.		52·5	16·2	14·8	1·4
Neu Iserlohn, very fine	78·7	21·3	13·0	8·3	78·7	21·3	11·2	10·1
Pluto, do.	101·6	21·8	13·6	8·2	108·2	21·8	13·1	8·7
Eintracht-Tiefbau, do.	68·8	15·5	9·4	6·1	88·6	15·5	7·5	8·0
Sieper and Mühler, fine	65·6	16·9	No analysis.		75·4	16·9	11·0	5·9
Deutscher Kaiser, very fine	...	...	...	...	52·5	26·9	20·0	6·9
D.—Aix-la-Chapelle.								
Union Company's Pits at Kohlscheid, coarse dust	19·7	...	No analysis.		26·2	...	No analysis.	
Union Company's Pits near Mossbach, coarse dust	19·7	...	No analysis.		29·5	...	No analysis.	
Maria bei Höngen, fine dust	42·7	11·9	10·5	1·4	65·6	11·9	No analysis.	
Anna bei Alsdorf, do.	52·5	18·7	10·0	8·7	72·2	18·7	No analysis.	
E.—Saarbruck.								
Griesborn, Walschieder Seam, coarse dust	39·4	37·1	No analysis.		52·5	37·1	31·0	6·1
Louisenthal, Beust Seam, fine dust	65·6	33·4	25·4	8·0	75·4	33·4	32·3	1·1
Von der Heyat, Heinrich Seam, medium dust	49·2	30·7	No analysis.		52·5	30·7	26·4	4·3
Reden, Grubenwald Seam, fine dust	65·6	30·6	25·1	5·5	62·3	30·6	24·2	6·4
The same, Kallenberg Seam, do.	49·2	35·8	No analysis.		65·6	35·8	26·0	9·8
Dechen, very fine dust	75·4	31·6	24·7	6·9	72·2	31·6	19·3	12·3
Dudweiler, Seam 13	59·0	28·3	16·8	11·5	65·6	28·3	17·6	10·7
The same, Seam 10, fine dust	59·0	33·1	23·9	9·2	72·2	33·1	25·0	8·1
Maybach, Seam A II., very coarse	39·4	32·6	22·1	10·5	49·2	32·6	21·7	10·9
Camphausen, fine dust	62·8	...	No analysis.		72·2	...	No analysis.	

flame from the shots stemmed with Dechen dust was from 29·5 feet to 52·5 feet long, whereas those shots stemmed with the Fuchs Pit dust gave a flame of from 65·6 feet. It will be apparent, then, that when both the sorts of dust are considered together, their elementary analyses must differ but slightly, and that the analysis of the coke would be almost exactly the same with both. It must, however, be observed that the dust of the Dechen Pit was very fine, whereas that from the Fuchs Pit was coarse-grained, and also, that in all cases, in order to obtain a solid resistance, only the very finest particles of the dust were used for the purpose of stemming.

The following table gives the ultimate analysis of the ash and water free substances of the different sorts of coal-dust placed in order of the length of flame given when they were used with clay stemming :—

Description of Coal.	Length of Flame.	Elementary Analysis.		
		C.	H.	O + N.
1. Union Co.'s:—	Feet.			
(a) Kohlscheid	19·7	No analysis	...	...
(b) Morsbach	19·7	do.	...	...
2. Cons Fuchs Pit	23·0	82·07	5 22	12·71
3. Karl Georg Victor	39·4	88·41	4·81	6 78
4. Hansa	39·4	88·90	4·65	6·45
5. Griesborn	39·4	77·64	5·54	16·82
6. Maybach	39·4	83·17	5·05	11·78
7. Maria bei Höngen	42·6	90·94	4·20	4·86
8. Dahlsbusch	49·2	85·65	5·18	9·17
9. Zollverein	49·2	83·24	5·14	11·62
10. Von der Heydt	49·2	80·11	4·44	15·45
11. Reden Kallenberg	49·2	76·03	4·93	19·04
12. Anna bei Alsdorf	52·5	88·47	4·75	6·78
13. Schaumburg (Obernkirchen)	59·0	86·73	4·33	8·94
14. Dudweiler Seam 13 ...	59·0	83·12	5·62	11·25
15. Dudweiler Seam 10 ...	59·0	82·98	5·33	11·69
16. Camphausen	62·3	No analysis	...	...
17. Rhein-Elbe	65·6	84·79	6·31	9·08
18. Sieper and Mühler	65·6	87·05	5·33	7·42
19. Louisenthal	65·6	79·06	4 37	16·57
20. Reden, Grubenwald ...	65·6	80 03	4·71	15·62
21. Friedenshoffnung	68·9	85·65	5·44	8·91
22. Eintracht-Tiefbau	68·9	84·93	4·45	5·62
23. Hibernia	75·4	87·50	4·98	7·52
24. Dechen	75·4	81·14	5·66	13·20
25. Neu-Iserlohn	78 7	No analysis	...	...
26. Pluto	101·7	87·38	4·72	7·90

The dry sorts of coal from Kohlscheid and Morsbach give the shortest length of flame, with the exception of that from the Fuchs Pit, which, from reasons before mentioned, does not seem to be in its proper place. The longest flames are from the Neu-Iserlohn and Pluto Pits.

When these experiments are arranged according to the size of the particles of dust, they stand as follows:—

Description of Coal.	Nature of Dust.	Length of Flame with Clay Stemming.
Pluto	very fine	101·7
Neu-Iserlohn	„	78·7
Hibernia	„	75·4
Eintracht-Tiefbau	„	68·9
Dechen	„	75·4
Friedenshoffnung	fine	68·9
Oberukirchen	„	59·0
Rhein-Elbe	„	65·6
Sieper and Möhler	„	65·6
Maria bei Höngen	„	42·6
Anna bei Alsdorf	„	52·5
Louisenthal	„	65·6
Reden, Grubenwald	„	65·6
Redan, Kallenberg	„	49·2
Dudweiler Seam 13	„	59·0
Dudweiler Seam 10	„	59·0
Camphausen	„	62·3
Karl Georg Victor	medium	39·4
Dahlsbusch	„	49·2
Zollverein	„	49·2
Von der Heydt...	„	49·2
Fuchs Pit	coarse	23·0
Kohlscheid	„	19·7
Morsbach	„	19·7
Griesborn	„	39·4
Maybach	„	39·4
Hansa	very coarse	39·4

From these tables it appears that length of flame is entirely due to fineness of dust; and definite variations in size give fairly determined differences in the length of flame.

	Feet.		Feet.
These vary with very fine dust between ...	68·9	and	101·7
„ „ fine dust between	42·6	„	68·9
„ „ moderately fine dust between	39·4	„	49·2
„ „ coarse dust between	19·7	„	39·4

Regarding the very great differences which the fineness of the dust seems to make in the length of the flame, other influences are also undoubtedly present. For instance, the chemical composition of the coal. It will be possible, however, to get a clearer idea of these effects when only dust of the same size of grain is used, and strewed, not only over 33 feet, but perhaps to a length of 98·4 feet. It has already been contemplated to take this into consideration in the experiments which have to be made; and it is proposed, as a rule, that the several dusts shall be passed through a sieve of ·039 inches, which, however, will not produce that flour-like appearance which is found in some of the Westphalian dusts.

Results of shots in a perfectly diffused mixture of pit gas without sprinkling of coal-dust.—The programme of experiments for these, and for future experiments, adopted a certain fixed proportion of gas, say of 1, 2, 3, 4, 5, &c., per cent.; but it was, unfortunately, impossible to keep strictly to these proportions, because the analysis of the gas in the gasometer was wanting. On the 1st of April, 1884, an analysis was taken of the gas coming out of the blower, which gave the following:—

CO_2 = ·65 per cent.
CH_4 = 84·89 „ } 86·51 per cent.
C_2H_6 = 1·62 „ }
O+N= 12·84 „

Considering that the distance from which the gas came from the blower to the gasometer was 3,608 feet, it was not to be expected that it should remain unchanged; so that for this reason 80 per cent. of CH_4 in round numbers, was taken in the calculation. Later, when at several times analyses had been taken from the gasometer, nearly the same result was obtained as that given above, and an average of eight analyses gave a proportion of 86·183 of CH_4, this was taken in all the other calculations. Therefore it will be seen that the proportions proposed in the programme were always exceeded.

The tables below give the results of the above analyses, in which the difference between CH_4 and C_2H_6 is not given.

Day of Expt..	10th July.	12th July.	15th July.	11th August.	13th August.	15th August.	19th August.	Taken at the Blower, April 1st.	Average.
CO_2 ...	0·49	0·69	0·55	0·55	0·75	0·53	0·81	0·65	0·628
CH_4 ...	86·35	86·48	86·53	84·82	86·43	86·36	86·88	86·51	86·183
O + N ...	13·16	12·83	13·82	14·63	12·82	13·11	12·31	12·84	13·190

By the experiments in question, the amount of gas in the space described as No. 1, holding 706 cubic feet was ascertained, and diffused by means of shaking canvas cloths, which were large enough to very nearly fill the cross section of the gallery. The man who conducted this work remained in the space during the influx of the gas, and began to diffuse it when no more was being admitted, which was made known to him by the attendant knocking at the side of the gallery. The diffusion took from two to three minutes, and its perfect equality was tried sometimes by a Pieler and at others by a Marsaut or Davy lamp. When in going through the chamber, the same length of flame appeared to come from the lamp when at the top and the bottom of the gallery, the diffusion

was considered as complete. The person who made these trials arranged the flame of his lamp outside the gallery, and then went into the space when the beating with the canvas had been stopped for some time. Imperfect diffusion was shown distinctly by the flame of the lamp, and it may be noticed that there was in some cases an excess of gas a little below the middle of the gallery, where a stronger mixture was found than at the top or the bottom, and this was mostly the case when the person had moved about the chamber shortly after the beating with the cloths had taken place.

The Trials with the Pieler and Davy Lamps.—This seems a proper place to remark upon the effects which the different percentages of CH_4 had on the light of the lamp. The necessary trials were made principally with the Pieler and Davy lamps, and carried out only by night; this was done so as not to subject the eye of the observer to the dazzling influence of a change from darkness to daylight. The light of the flame was tried first outside the gallery in fresh atmospheric air, and arranged so that the top of the flame of the Pieler lamp came up exactly to the top cant of the chimney, and that of the Davy lamp so that it was about ·2 of an inch high; this could have been made lower, but it was feared that by making it so the lamp would have gone out before the result was obtained.

The following results were obtained:—

LENGTH OF THE FLAME.

Per Cent.	Pieler Lamp, above the Chimney.	Davy Lamp, altogether.
1	1·58 to 1·97 inches	No perceptible lengthening of flame.
2	2·76 to 3·15 inches	Ditto.
3	4·72 inches	·59 inches.
4	The flame reached to the top of the cover of the gauze and was extinguished. The distance from the upper edge of the chimney was 5·9 inches	1·58 inches.
5	The flame reached the top of the lamp and was extinguished The distance from the point of the bright flame to the top was 5·4 inches.	

The percentage proportions were fixed by calculation.

These experiments were made on the whole seven times in a period of three weeks, and not more than one in the same day. The results remained nearly always the same when the Davy lamp was used, whereas by the Pieler lamp the variations described were observed. The time which was occupied in the observations was at least five minutes, and in some cases ten minutes, during which time trials had been made in a large number of places. The Pieler lamp was fed with pure alcohol.

Of course these experiments could only be expected to give approximate results: firstly, the space could not be so absolutely shut up that no gas could escape, and secondly, there were losses caused by going in and out of the space; so that it might be taken that in the adjoining space, which held 62 cubic feet, when they were trying with the higher percentages of gas with the Pieler lamp, they obtained caps from ·78 to 1·18 inches long. However, it was not the object to get altogether absolute formulæ, for it is clear that the quantity of CO_2 in the mixture was not without an influence upon the length of the flame; besides, after all the trials, when the length of the flame had been settled, samples of every mixture of gas, together with samples of the gas in the gasometer, were taken and sent to be analysed at the laboratory, Bochum, and it was there found that the following were the results:—

Constituents.	In the Gas in the Gasometer,	In the Mixtures of				
		1 per Cent.	2 per Cent.	3 per Cent.	4 per Cent.	5 per Cent.
	Per Cent.					
CO_2	1·110	0·428	0·308	0·363	0·258	0·231
CH_4	86·443	0·891	1·749	2·734	3·676	4·684
O + N	12·447	98·681	97·943	96·903	96·066	95·085

By the above table it will be seen that the percentage of CO_2 in the gasometer gases is not altered very much from that given before, whereas the percentage of CH_4 and O + N remains almost the same, and does not vary very considerably from the average calculations. The other analyses prove that a certain portion of the CH_4 is lost, but this difference is much less than was expected, so that it could have very little influence upon the length of flame in the foregoing trials.

The most extraordinary feature is the difference in the proportions of CO_2 in different analyses. The writer thinks that, in this respect, the presence of a man, sometimes three men, and the burning of the lamp in the chamber had very much to do with it; and this seemed also to be borne out by the fact that in the mixtures of one per cent. of CH_4 they were a long while in the chamber. It must be mentioned that, fortunately, this was advantageous to the general diffusion of the mixture.

In the experiments which were made according to the programme, of pit gas without the strewing of coal-dust, with a perfect diffusion, the holes 6 and 7 were again used and stemmed with clay. Here, with percentages of 1·180, 3·209, 3·539, 4·718, and 5·898 of gas, there was a length of flame of from 23 to 45 feet, and also about the same results, when the coal-dust from the pit Hansa or Dechen was used to stem the shots.

With 7·077 of CH_4 the flames reached from 108·2 to 116·8 feet in length, and the results could be compared with those obtained when 23 feet of coal-dust from the pit Pluto was strewed, and the shot stemmed with coal-dust. The colour of the flame in these experiments was yellowish. When they were stemmed with coal from the König pit, the results, with a percentage of 1·180, 2·359, 3·539, and 4·718 of gas, were not very different from one another. The length of flame varied in the first experiments between 29·5 and 42·6 feet; and in the second, between 49·2 and 72·2 feet. This result was also obtained with a clay stemmed shot, by strewing coarse, and sometimes fine, dust.

It is to be remarked that in the first experiments the stemming was with medium dust, and in the last experiments with fine dust.

When the percentage of mixture was from 5·898 to 7·077 the length of flame varied, with average dust stemming, between 88·6 and 141 feet, and with very fine dust stemming, from 114·8 to 144·3 feet. The greatest difference in these experiments between clay and coal stemming was between 26·2 and 29·5 feet.

Two heavy explosions were observed after the shots with the last named quantity of gas, and the colour of the flame varied between yellow and red.

Experiments with respect to explosions of pit gas without perfect diffusion, by means of direct electrical firing at different levels.—The fifth portion of the programme explains trials in respect of explosions of gas which was not perfectly diffused, by firing it by electricity at different levels. These experiments were made in the first space at ·36 feet and 14·1 feet from the usual opening for the admission of the gas; and, in order to effect the firing of the gas, two wrought-iron round rods of about ·2 inches thick, and of the description given in Fig. 6, Plate XXXVIII., were passed into the gallery through two well-fitting holes which were open from the roof. These rods were so long that when they were ·2 inches above the bottom of the gallery they stood 7·8 inches above the top of the gallery in the air, and had projections at their ends, to carry the wires of the electrical machine. The other two ends which were in the inside of the gallery (*a a*), were ·2 inches apart from each other, and just above there was a ring (*b*), for the purpose of drawing them to or from each other.

These experiments were so arranged that they commenced when the percentage of gas was from 7·077 of CH_4, and the ends (*a a*) of the little rods were placed at a height of 1·6 feet above the bottom, and they had often to be drawn 3·9 inches high before the electrical spark fired the gas.

238a 38

After the after-damp had disappeared the chamber was again filled with the next percentage of CH_4, then if the sparks were not high enough to take effect, the rods were taken up higher. The following are the results obtained:—

a. AT THE FIRST FIRING PLACE.

Percentage of CH_4.	The height above the Floor at which the Gas fired.	Length of Flame.
7·077	2·6 feet	121·4 feet.
5·898	2·6 „	127·9 „
4·718	2·6 „	75·4 „
3·539	2·6 „	45·9 „
2·359	4·6 „	19·7 „
1·180	No explosion could be obtained when the wire was at its highest place.	

b. AT THE SECOND FIRING PLACE.

Percentage of CH_4.	The height above the Floor at which the Gas fired.	Length of Flame.
7·077	2·6 feet	88·6 feet.
5·898	3·3 „	78·7 „
4·718	3·3 „	78·7 „
3·539	4·0 „	45·9 „
2·359 } 1·180 }	No explosion could be obtained.	

From this it became certain that the pit gas, when it came in, rose perpendicularly, and then disseminated itself in uneven planes along the top of the gallery.

In Fig. 7, Plate XXXVIII., an attempt is made to show the length of the different layers of gas of different percentages by means of dotted lines, the direction of the axes of the shots being made by alternate dots and lines.

The time which was taken in adjusting the rod was between two and three minutes. This flame showed a yellow colour.

The results of the shots in gas without coal strewing and without diffusion.—In addition to the above-named experiments some were made which were not in the programme, with respect to the results of shots in gas without coal strewing and without diffusion, and with clay stemming.

Shots were first fired out of the hole No. 6, in which it was only when the proportions of gas reached from 5·898 to 7·077 CH_4 that the flame differed greatly from the usual length when clay stemming was used, and extended from 26·2 to 131·2 feet. With the hole No. 4, with proportions

of gas of 7·077, 5·898, 4·718, and 3·539 per cent., lengths of flame of 154·2 feet, 127·9 feet, 98·4 feet, and 26·2 feet were obtained, whereas those with 2·359 per cent. gave the same results as ordinary shots. With shots out of hole No. 1 (with all percentages of mixture, from the highest, 7·077, to the lowest, 1·180) lengthening of the flame was observed, and distinctly traced for lengths of 118·1, 101·7, 78·7, 36·1, and 23·0 feet, the shorter distances for the lower percentages of gas. (See Fig. 7.)

Trials in respect to the explosion of gas with perfect diffusion both with coal-dust stemming and coal strewing.—The following extracts from the programme show the experiments in respect of explosions of perfectly diffused gas, when the shots have been stemmed with coal-dust, and coal has been strewed about. For the latter purpose the dust from the König Pit, passed through a sieve of ·275 inch openings, was used, and the shot-holes were those nearest the thill, Nos. 6 and 7. The percentage of CH_4, with which the experiments were made, was as follows :—1·072, 1·180, 2·145, 2·359, 3·217, 3·539, 4·289, 4·718, 5·898, and 7·077.

The strewing of dust varied from 33 feet to 49·2 and 65·6 feet long, and the results with the first seven different percentages of gas, and with the three variations of strewing, were flames of from 36·1 to 75·4 feet long, whereas by the three following higher percentages the results given below were obtained :—

Feet.			Feet.		Feet.		
By 32·8 long, sprinkling	...	72·2	to	121·4,	length of flame.		
„ 49·2 „ „	...	75·4	„	167·3,	„	„	
„ 65·6 „ „	...	78·7	„	170·6,	„	„	

When these experiments are compared with those made with coal stemming, and complete diffusion without coal strewing, it is found that in the lower percentages the lengths of flame remain pretty nearly the same, whereas, by the higher percentages, very important differences occur.

The longest of these flames, however, does not reach anything like so far as that produced when the Pluto and Neu-Iserlohn dusts were strewed 131 feet long and subjected to a shot stemmed with coal-dust.

Unfortunately, there was not dust enough at hand from the last-named pits to carry out the above experiments under the same circumstances. Only three experiments were made, two with Pluto, and one with Neu-Iserlohn dust. The experiments with the first were made with 33 feet of strewed dust and a percentage of 2·145 of CH_4, and with 65·6 feet of strewed dust and 7·077 CH_4; with the last 65·6 feet were strewed, and 4·718 per cent. of CH_4 was used. The first of these experiments had a flame 118·1 feet long, and the two others flames of 170·6 and 193·5 feet.

The results of all these experiments necessitated drawing up another programme, instituting experiments between the Neu-Iserlohn and König dusts with the 33 feet strewing, and with CH_4 in exact quantities of from 1 to 6 per cent.; and as the dust taken from the Neu-Iserlohn Pit used in these experiments was very small, the König Pit dust was passed through a sieve of ·04 inch holes. In order to obtain a reasonably exact result, every experiment was tried three or four times over. The quantities of gas were reckoned from the average analysis, and No. 6 hole was used with clay stemming.

The experiments gave the following results :—

CH_4.	Average Results.—Length of Flame.	
	König Dust.	Neu-Iserlohn Dust.
	Feet.	Feet.
0 per cent.	45·9	49·2
1 „	49·2	62·3
2 „	52·5	78·7
3 „	65·6	95·1
4 „	82·0	101·7
5 „	114·8	118·1
6 „	134·5	154·2
	—	170·6

On looking over this table, it is seen that the flame with the Neu-Iserlohn dust is decidedly shorter, without the presence of CH_4, in comparison with earlier observances under the same circumstances. It appeared afterwards that the second delivery of this dust had come from another part of the pit, a circumstance which has not yet been satisfactorily accounted for.

Generally these results mark, most clearly, the powerful action of the Neu-Iserlohn dust, the flame from which, in many cases, exceeded by 19·7 to 23·0 feet in length that obtained from the König dust. The colour of the flame in all these experiments was orange.

Experiments with regard to extending an explosion to distinctly separated mixtures of gas through the sole instrumentality of coal-dust.—The last details of the programme in chief give directions for experiments with regard to extending an explosion between two distinctly separated mixtures of gas through the sole instrumentality of coal-dust. These experiments were made in the principal gallery, before the side gallery was put on, and produced no results, because the gas was always driven out by the original explosion; but it is intended to carry on these experiments, using the side gallery as a place in which to insert the

second quantity of gas, and then the other projected experiments of the the supplementary programme will also be carried out.

In all the experiments already described the principal object has been to determine the length of the flame. It is now necessary to make some remarks as to the quickness of the flame, and the production of coke and after-damp; and lastly, to say a few words about the mechanical effect of certain shots.

Speed of the flame.—With respect to the speed with which the flame rushed on in several experiments, it is to be remarked that all of these, without the presence of CH_4, with the exception of some in which lengths of about 65·6 feet were strewed with Pluto and Neu-Iserlohn dust, seemed to have a speed of about 3·3 feet a second, whereas, in the exceptional cases, the flame commenced with smaller velocity, but afterwards flashed along as quick as lightning.

With the presence of CH_4, in percentages of from 1 to 4 of gas, the speed of the flame did not much exceed 3·3 feet per second, whereas, with a large percentage of CH_4, lightning speeds were obtained. One exception in the first case was, nevertheless, apparent, in which 33 feet of Pluto dust was strewed, and with the presence of 2·145 per cent. of CH_4, the flame flew with lightning speed.

What has been said respecting the swiftness of the flame seems very important, as affording an interpretation of what has frequently been said by witnesses, and recorded in proceedings, viz., that, in accidents of this nature, the flame comes slowly forward.

Formation of coke.—It must be remembered that the production of coke depends very much upon the quality of the coal used; and it is very easy to discern when the shots are fired, without gas, from the greater or less quantity of coke that is made, whether it is a good or bad coke-forming coal which has been used. This, however, is different with the presence of higher percentages of CH_4, for here, in almost all cases, the formation of coke is much less perfect and much smaller than without the presence of gas. There is also a notable falling off in the formation of crusts and knobs of coke hanging upon the woodwork and projecting parts of the gallery. This almost seems to prove that where the shot has been fired in a pit, and good, well-formed coke is found afterwards, that the dust has played a greater part in the explosion than the presence of gas. The reason why, when gas is present, less coke is formed, may be attributed to the quickness of the flame.

The most coke is found in the space close to the window No. 6. This is probably caused by the already mentioned peculiar appearances of flame

in the first windows of the gallery. It was often remarked that the coke in this place, after twenty-five minutes, was so hot that one could not hold it in the bare hand for any length of time.

The formation of soot which occurred here with the finest sorts of dust, especially with that from the Pluto, Neu-Iserlohn, and Camphausen Pits, was remarkable; and also the curious way in which, in the cross section of the strewed mass, coke was bedded on the top in a layer of soot 4 inches thick, whereas, underneath, the coal-dust still remained unchanged.

After-damp.—The most important quantities of after-damp always appeared where the flame length reached very far, and the observer came to the conclusion that the evil consequences of the after-damp on the human organism was very much more dangerous than that which resulted from the action of the gas.

The after-damp appeared to the eye directly the coal-dust strewing was used, like a brown or dark grey cloud, whose colour resulted chiefly from small particles of soot which were always mixed with it. The quantity of these small particles of soot was according to the quality of the dust. That, for instance, which came from the experiments with the Pluto and New-Iserlohn dust was so great that objects standing in the neighbourhood of the after-damp became suddenly covered over with a mass of soot.

Without the presence of coal-dust, flame in the after-damp was always brighter, and it was also possible to remain in the smoke for a short time, whereas when the after-damp came after experiments where coal-dust had been used there was generally a very strong smell of tar, and a very much higher temperature than in the former cases, which immediately caused very great difficulty in breathing. It is particularly remarkable that in these cases the Pluto dust, through the greater length of its flame, lost not less than two-thirds of its volatile products.

Effect of the shots.—The mechanical effect of the shots has yet to be considered. In order to mark these plainly, in front of the end of the gallery a railway was put down, with an upward inclination of four degrees, and a tub was placed outside, so that one end was exactly in a line with the opening of the gallery, in the same way as is shown in Fig. 5, Plate XXXVIII. On the fore part of the tub hung a small rod, which, as the tub went forward, made a mark in the damp clay, so that it could be ascertained exactly how far the tub had been thrown.

These different effects were proved in the experiments in the new programme, which were instituted to try the effects of strewing 33 feet

of the Neu-Iserlohn and König coal-dust, of different sizes, in the presence of gas. The result of these experiments is given below :—

Percentage of Gas.	Effect of the Shots.			
	König Dust.		Neu-Iserlohn Dust.	
	Weight of Tub.	The Tub was thrown	Weight of Tub.	The Tub was thrown
	Lbs.	Feet.	Lbs.	Feet.
	650	2·19	650	2·6
1 per cent. ...	650	3·05	650	3·93
2 „ ...	650	3·3	650	4·92
3 „ ...	650	4·1	650	7·21
4 „ ...	650	7·5	650	8·52
5 „ ...	650	10·8	1,623	11·1
6 „ ...	1,166	21·3	1,623	20·6

This shows that the dust from Neu-Iserlohn has a very much stronger effect than that which comes from the König Pit, in other words, the effect is as the length of flame. It was necessary for this reason to alter the weight of the tub, because it was found that the heavy blows it had received drove it off the line; that is, it drove it further than the line reached.

By these experiments, with the presence of from 5 to 6 per cent. of CH_4, two heavy blows were experienced, nearly always together, but in some cases following each other with a pause of from two to three seconds. When the latter was the case, the working of the blows upon the tub could be distinctly observed and it was found that the first blow was always the weaker, and only moved the tub, at the most, about a yard, and that too in a very quiet way; whereas, the second, the hardest, shook it severely and then drove it out with immense velocity. In no case was any drawing back of the wagon remarked.

With different sizes of dust the following results were given :—

Size of Dust passed through Sieve of	Effect of the Shot.			
	Clay Stemming.		Coal Stemming.	
	Weight of Tub.	Tub was thrown	Weight of Tub.	Tub was thrown
Inch.	Lbs.	Feet.	Lbs.	Feet.
·04	645	2·46	645	6·9
·12	645	2·52	645	6·8
·24	645	1·98	645	6·6
·40	645	1·64	645	6·9
·60	645	1·70	645	7·5
·80	645	1·41	645	4·9
·12	645	1·31	645	3·11

Comparing the results of the clay and coal stemming, it will be found here again that the larger size of the dust, to some extent, increases the effect of the explosion.

Remarkable also were the effects of two shots, without gas but with 141 feet strewing of Pluto dust and clay stemming, the results of which, however, were very different.

The first shot moved the wagon, laden with 645 lbs., 24·2 feet, whilst the other threw it violently 40 feet away. This gave an opportunity of understanding the enormous explosive power of the Pluto dust.

MARGRAF,
Mines Inspector.

The PRESIDENT said, he was sure that they all had been extremely interested in hearing Mr. Bunning's explanation of these very important experiments. The translation of the full report would be printed and distributed in the usual way, and the members would have an opportunity of reading it fully and considering it. They were favoured that day with the presence of Mr. Galloway, who, he believed, was the first person to draw attention to this subject, in a paper which he read many years ago before the Royal Society. Before asking any other member to join in the discussion, he would request Mr. Galloway to kindly favour them with some remarks. Mr. Galloway had been at the place where the experiments had been carried on, in Germany, and had seen some of them tried.

Mr. W. GALLOWAY said, that, as the President had remarked, he had for some years been making experiments with coal-dust, and on hearing about these German experiments, he naturally took great interest in them, and proceeded to Germany on the invitation of Dr. Gurlt, a well-known mining engineer. He was accompanied by Mr. Wm. Thomas Lewis, one of the Royal Commissioners on Accidents in Mines. In the paper, reference was made to the Camphausen dust; this mine had since exploded, and more than 100 men had been killed. He saw experiments made with the Pluto dust from Westphalia, of which Mr. Bunning had said so much; and the one point that particularly struck him was that the Pluto dust not only lengthened the flame from the shot, but produced an actual explosion. There was no doubt whatever about that. A good many of the experiments which Mr. Bunning had described as having been made with the Pluto dust, were made with dust strewn from the shot-hole,

to a distance of about 10 metres along the gallery, and consequently in those cases it only produced a lengthened flame ; but the experiments seen by Mr. Lewis and himself were made with dust strewn to a distance of from 131 to 164 feet, and then the effect was simply an explosion such as one might expect from gas. The small pit wagon, at the end of the gallery, was driven from 40 to 50 feet away, with great violence. They could not positively state whether there was any lapse of time between the firing of the shot and the arrival of the flame at the end of the gallery ; the two incidents seemed to be simultaneous. Mr. Lewis was thoroughly convinced that Pluto dust would explode. Neu-Iserlohn dust was just the same as thePluto dust in this respect. It produced the same phenomena when acted on by a shot. The German experimenters came to the conclusion that all the other dusts tried by them were more or less harmless ; but, to his mind, they were rather hasty in coming to that conclusion; and the explosion which has since occurred at Camphausen Colliery seemed to support what he said. Camphausen was one of the largest collieries in Saarbruck, and a great many men were employed—from 150 to 200 at the time of the explosion. It was said that the explosion travelled throughout the whole of the workings, and it was admitted there was hardly any gas present in the mine before the event. In fact, it was one of those explosions, similar to many great explosions which had been seen in this country, in which it had been afterwards found, on investigation, that there were no previous accumulations of gas, and consequently no one had been blamed, and properly so. To his mind, the subject was not then properly understood. As he had said, at Camphausen the explosion travelled throughout the whole length and breadth of the mine, and produced phenomena similar to an explosion of gas. In the German experiments Camphausen dust was a long way down in the list of dusts in regard to relative danger. According to one of the tables given, there were 10 dusts which gave longer flames than Camphausen dust. The shortest flame given by these 10 dusts was 65·6 feet, Camphausen being 62·8 ; and there were other 3 dusts which gave flames of 59 feet in length. So that, altogether, they had 14 dusts which gave flames sensibly equal to, or greater than, Camphausen dust ; that is to say, 14 of the 28 dusts.* What he wished to draw serious attention to was this —that if the Camphausen dust, which was only the 11th on the list, could give rise to a great explosion, such as had occurred in that colliery, then it was obvious that the other 10 dusts were

* It should be carefully noted that the flames here spoken of were obtained with a strewing of dust 10 metres (33 feet) long in each case, and not with a strewing of indefinite length.

equally liable to give rise to similar explosions; and the inference was, that out of the whole 28 dusts, they might actually take it that at least 14 were dangerous. In saying that the 14 were dangerous, he ought to qualify this by the next remark. Of the dusts tabulated by the German experimenters as not being dangerous, a good many were very coarse, and it was found that by sifting them through a fine sieve, the length of flame was very much greater than when they were employed in their original state; so that, if it had been possible to employ the whole of the dusts in a state of fineness, it was certain that different results would have been obtained with the remaining 12 dusts. He did not think any general conclusions could be safely drawn until experiments of this kind had been undertaken. The experiments described with König dust were very striking. Dust sifted through a sieve having meshes one-eighth of an inch square, gave a length of 46 feet of flame; and, on being sifted through sieves with larger meshes, the length of flame was reduced to 27 or 30 feet, proving incontestably that the coarseness or fineness of the dust had very great influence. When a colliery explosion had once started—they need not inquire how it was started at the present moment—but supposing it had been started, it was obvious there was a blast of air passing through the mine. That blast of air raised the dust in a whirlwind—coarse and fine dust together—consequently they had fine dust in the air, and the flame passing along, had the opportunity of igniting that fine dust. If there was a very large proportion of coarse particles in the air, the flame would not travel so fast; but if there were few coarse particles in the air the flame would pass on more rapidly. His opinion was, that when this state of matters existed the flame was simply delayed a little by the coarse particles; but that it passed through all the same. The German experimenters had, he thought, drawn their conclusions rather hastily in some respects. He, for one, was very heartily pleased with the experiments they had made, and he thought they had carried them out in that very exhaustive and thorough manner for which Germans are so celebrated. He should be very sorry indeed were the Germans not to carry them further. He thought it was intended to continue the experiments, and to endeavour to arrive at some further practical results from them. There was one point he would like to mention, and it was that some of the experiments were made without any strewing of dust close to the shot-hole. A space of 10, 12, or 20 feet was left without any dust, and then dust was strewn further along the gallery; and they found in these experiments, that the flame of the shot was not prolonged at all, but was of its ordinary length.

The flame of the shot did not pass over the space which had been cleared of dust. This, to his mind, was one of the most practical results attained, and indicated that if dust was removed from the immediate neighbourhood of the mouth of the shot-hole, they would remove the principal danger of shot-firing. The Monmouthshire and South Wales Collieries Association had endeavoured to get the Home Office to take the matter up some time ago, and to allow them to make a rule that the space in front of each shot-hole should be watered for 5 or 6 yards, and they thought that in this way they would avoid the danger. He thought that the last-named experiments of the German Commissioners proved, to a large extent, that danger would be removed by such an operation.

Mr. Richard Forster thought it was important to accept the portions of the paper which were adaptable to the working of the mines they had to do with in this country. It would be well to consider the paper generally with a view to singling out the points which might be of service in practical mining, and separating them from those points which had not been shown to bear on this at all. As he understood the matter, the experiments were carried out with dust in a state of diffusion in the gallery. They all knew, in practice, that in mines dust was not in a state of diffusion. The shot would cause diffusion; but the diffusion did not exist in a mine before the shot was fired, and this prevented these experiments indicating what would happen under the ordinary conditions of pit working. In the summary which Mr. Bunning had given, they were told that, in the opinion of the German experimenters, practically, no explosion would occur, even under conditions specially and exceptionally favourable to causing explosions—unless from blown-out shots. It seemed to him that the question narrowed itself into what would arise under ordinary circumstances in the pit with blown-out shots. He thought he was right in saying that the first experiments which were made without dust in a state of diffusion in the gallery, and with simply a coating of dust on ledges made to receive it, such as would be found in the regular ordinary workings, signally failed. He was not making these remarks with a view to disparage the experiments, but simply to point out what he thought was useful, and that which he thought did not bear on mining in this country. He could not speak of Germany. He knew that in mining, in ordinary cases, dust was quiescent; and he did not think that these experiments, although useful, were of real value for the ordinary working of a mine. Then came the question—what did cause the explosions? Where dust was set in great diffusion by explosion, there was no doubt that it extended the

explosion in a mine to a great distance. He was satisfied, from his experience of what he had seen in Durham and Northumberland, that they had no dust in existence that would fire from a shot unless there was gas with it. That dust would ignite, he believed. A case came under his own experience where the apparatus chain connected with the winding engine broke, and it set the dust up, which took fire at the light, and the flame burnt one man so severely that he had to be taken home, but the dust did not explode. The other man employed at the same screen was not burnt. The dust in that pit was very fine, and he had brought a box-ful with him, and would be glad if Mr. Galloway could say whether the German dust was as fine. They should be careful to take what was useful in these experiments, and leave out what was not applicable to this country. He had seen an engine-plane set running at 12 miles an hour, and the current travelling 800 or 900 feet a minute, and a perfect cloud of dust raised from top to bottom, so that he could not see the guard or run-rider sitting on the last of the set with a large open torch-light, and, after hearing the experiments detailed in the paper, he could not see why, under such conditions, there should have been immunity from explosion. He was not disparaging the German experiments, but would encourage them in every way; but the members need not discuss any part of them that really did not become applicable to the working of mines in this country. The great object this Institute had in view was to prevent the loss of life; but it would entail a hardship, not only on the coal-owner and the workmen, but also upon the nation, if there was put upon the working of coal an incubus, which really did no good, and only cost the nation a great deal of expense.

Mr. W. H. Wood asked if the members were correct in assuming that the experiments in Germany were conducted with dust in suspension five minutes before the shots were fired? He understood from what Mr. Galloway said, that when the dust was not in suspension, and where it lay on ledges, to assimilate the condition of things in the gallery to what they would be in a pit, and where all was at rest until the cannon was fired, that the result was not great, so far as the flame was concerned. It would be satisfactory to have this explained.

Mr. Bunning said, the report did not give the details of the experiments made where the dust was placed on ledges; the experimenters merely said they did not consider it necessary to repeat them, as the ordinary mode of strewing answered the purpose as well. With respect to the dissemination of the dust, he would be very much obliged if Mr.

Galloway, who had been in Germany and seen the experiments, would tell the members whether the dust was disseminated on all occasions, or only on special occasions.

Mr. GALLOWAY said, he imagined that the raising of the dust in a cloud was only done occasionally—say when the centre and upper holes were fired. He understood from what Herr Margraf, who made the experiments, said to him, that the lower shot-holes raised the dust for themselves, that there was no necessity to raise dust artificially for them. The lower holes were so close to the bottom that the firing of the shot caused a whirlwind to take place, and raised the cloud of dust, which was fired. Mr. Forster had referred to this point, and had spoken of the cloud of dust which was raised by a train of wagons travelling at a high rate of speed. According to all the experiments he (Mr. Galloway) had made, it was impossible for a man to live in air containing a sufficient quantity of dust to render it inflammable. It had to be perfectly black, so that they could not see a light through 2 feet of it, before it became inflammable or explosive. There need be no danger apprehended from dust suspended in the air by any ordinary mining operations. Of course, in the case referred to by Mr. Forster, where the dust was shaken off a chain, he (Mr. Galloway) took it there would be sufficient dust to make the air literally filled with dust, and it would take fire.

The PRESIDENT asked Mr. Galloway if, on the occasions when he saw the experiment, anyone went into the gallery to shovel the dust, or if the dust was simply lying on the floor?

Mr. GALLOWAY said, when he saw the experiments men went into the gallery, swept up the dust after each experiment, strewed fresh dust on the floor, and came out again; there would always be a lapse of three or four minutes after the dust was strewn before the shot was fired. The men had to travel a considerable distance, and any dust raised by them would have time to settle down, to a large extent, before the shot was fired.

Mr. W. H. WOOD—Mr. Galloway said that before dust could be exploded it must be in such a cloud that human life could not exist in it.

Mr. GALLOWAY—That is so.

Mr. W. H. WOOD—After the men had shovelled the dust in this gallery, would the dust be in that state?

Mr. GALLOWAY—It could not be, or the men could not have remained in it. The men were in the gallery when the dust was strewed in it.

Mr. W. H. WOOD—It is impossible to understand how, after the men had left the gallery, dust, in such a state as to become inflammable and

explosive, could exist in the gallery, and be raised in such a cloud that human life could not exist in it. If the men were in the gallery just before the explosion, the dust must not have been in that condition.

The PRESIDENT understood Mr. Galloway to say that it is the shots that raise the dust from its quiet state.

Mr. W. H. WOOD—Yes, when there was a low shot which boomed along the ground, and raised the dust, but not when the high shot was fired.

The PRESIDENT—They were mostly low shots?

Mr. GALLOWAY—They were all low shots.

Mr. A. L. STEAVENSON said, that since the doctrine was first promulgated that dust had a great influence in explosions, he had never heard anyone dispute it until to-day. It was a doctrine that had met with great acceptance among themselves and their workmen, and it was a doctrine that appealed strongly to their common sense. This had been a matter of experiment by Professor Abel, and by German and French Commissioners, and it did not remain a matter of doubt at all. He did not know whether they were all aware that Professor Abel found that magnesia and other dust, not in themselves combustible, would promulgate explosions to a large degree. He read the following statement by Professor Abel:—

"While the richness of a dust in coal, or its greater inflammability, influenced the rapidity and consequent violence of the explosion of dust and gas mixtures containing corresponding quantities of fire-damp, the physical characters and mechanical condition (lightness, porosity, and state of division) evidently contribute more than the richness in coal, or combustibility of the dust sample, to determine the comparative readiness with which it brings about the inflammation of a gas mixture not susceptible of ignition *per se* under otherwise similar conditions, and to regulate the proportion of gas required to produce, with it, a mixture which will ignite and *convey* flame, when coming into contact with flame. This is strikingly illustrated by the fact that the sample of Seaham dust containing the smallest proportion of coal, and consisting, indeed, of nearly half its weight of non-combustible matter, ranked next in sensitiveness to the samples which consisted almost entirely, or chiefly, of coal.

"The results obtained with this particular dust led me to try whether the ignition, by a lamp flame, of a mixture of fire-damp and air, not inflammable *per se*, would be brought about by suspending in it a fine readily-floating dust which was *quite non-combustible*, and not susceptible of any chemical change by exposure to a high temperature. The powder answering to these conditions, which was most readily procurable when this experiment suggested itself, was calcined magnesia. A gas mixture, having 3 per cent. of fire-damp, was allowed to pass a lamp flame at a velocity of 600 feet per minute for some time; no result was produced, but on causing it to convey calcined magnesia in suspension long flares of flame were produced within a few seconds of the mixture first passing the lamp, and the inflammation speedily spread throughout the gallery with feeble explosive effect. With only 2·75 per cent. of gas, results quite similar were

produced, the *general* ignition following, however, less rapidly after the first production of the flares in front of the lamp flame. With another sample of calcined magnesia, which was not quite so light as the first one, a corresponding result was obtained with a mixture containing 3 per cent. of fire-damp.

"In a still atmosphere containing 2·5 per cent. of coal gas, one of the most sensitive of the Seaham dusts (K), when suspended in it, produced ignition of the mixture, with no explosive effect. A corresponding result was produced by suspending calcined magnesia in a still atmosphere containing 3 per cent. of gas.

"It will be seen from these results that the perfectly non-combustible powder, magnesia is, in its power to bring about the ignition of an otherwise uninflammable mixture of fire-damp, or coal gas and air, little inferior to the most inflammable and sensitive of the Seaham dust samples."

They had the fact that coal-dust in the air did render a place more inflammable. There had been a large number of explosions in flour-mills, in which there was no gas, and a large number of people had been killed. The effect dust had in explosions did not appear to be a matter of dispute. They had not time to go further into the question to-day, and the discussion must be left over until the next meeting. He proposed a vote of thanks to Mr. Bunning for his translation of the report.

Mr. W. H. Wood said, in reply to Mr. Steavenson, that he (Mr. Wood) had not himself said that coal-dust was absolutely non-explosive. He admitted that coal-dust aggravated an explosion. But Mr. Galloway told them that the amount of coal-dust to be inflammable must be such that human life could not exist in it, and he (Mr. Wood) could not reconcile the two things—that men should go into a drift and stir up the dust, and come out, and then, when the cannon was fired, an explosion take place. Afterwards there was an explanation by Mr. Galloway that the lower holes were fired along the top of the dust, and this would account for it exploding. If human life could not exist in the cloud of dust before it became explosive, he did not think they could have such a case in their pits; sufficient dust could not be got off the baulks or the rolley-ways.

Professor Merivale said, there was one point of interest which had not been mentioned. It was a point which did not bear on explosions in mines. Mr. Bunning told them that oily coal-dust was more inflammable than non-oily dust. This appeared to bear on a question which was being investigated—the explosion of the air-receiver at Ryhope. When they got the translation *in extenso*, he hoped they would find something which would explain the explosion of oily dust.

Mr. Galloway said, he thought it should be strongly insisted upon, that Pluto dust created a true explosion. In the body of the report it was stated, in so many words, that the effect of all the experiments with

Pluto dust was to show that, however long the gallery might be, supposing the dust to be strewn equally far along it, the flame would pass along its whole length. This statement was made in large print in the body of the report, so as to make it more distinct, to the effect that Pluto dust was truly explosive. Mr. Lewis and himself were anxious to see the utmost that that dust would do, and, although they were very short of the dust, the experimenters strewed a greater length than usual to show them. When the shot was fired there was a very loud noise, like the firing of a great cannon, the flame came out of the mouths of the safety-valves and flew high into the air, and the after-damp filled the whole space over the pit heap. A wagon loaded so as to weigh 14 cwt. was driven 52 feet along the railway, rising at an angle of 4 degrees, it then left the rails and ran a further distance of 6 feet on the ground. The end of the wagon next the explosion was broken, the boards being actually staved in. There was a small baulk, about 4 inches square, placed across the rails, and bolted, to keep the wagon from running into the gallery; and this baulk was torn away from the bolts and thrown to a great distance over the pit-heap. The loose stones that were lying about the mouth of the gallery were raised in a great cloud, and thrown completely over the pit-heap. The brattice, about $1\frac{1}{2}$ inches thick, which was placed at the end of the branch gallery, was completely torn out and broken up. In fact, anyone had only to see that experiment to be convinced that coal-dust could make an actual explosion. He wished some of the gentlemen at this meeting had been able to see the experiments, and he would strongly recommend some of them to go and see them, and they would be completely convinced. He thought it had not been quite clearly brought out in the report why the German experimenters desisted from placing dust on the shelves in the gallery, which represented the cross timber in mines. The real reason was that the experimenters found it quite unnecessary to do so, as the shots raised the dust so easily; they, therefore, gave up putting it there, not because it had no effect, but because it was quite unnecessary.

The PRESIDENT said, they were very much obliged to Mr. Galloway for the interesting remarks he had made, although he (the President) was sorry they did not convey any sense of security to their minds, but made the fact rather more disagreeable. The determination of coal-dust exploding was not a point at which any person had arrived at all at once. At the first commencement of these experiments it was thought that coal-dust simply added to the effect of the explosion; it was not imagined that it would itself explode. It was also thought,

that even with a fast shot, dust could not be fired at the same time as it was raised; certainly, it had now been ascertained that the same shot would, under certain conditions, both raise the dust and fire the dust, which was a state of things they did not anticipate before. They should bear in mind, however, that these German experiments had been made for the sole purpose of making explosions with coal-dust, and not of preventing them, which was the chief object proposed by the members of this Institute. At the commencement of these experiments a very interesting fact was brought before them, and that was the difference in regard to stemming shot-holes with coal-dust and with clay. In the case of stemming with clay, it did not appear that, with an ordinary shot, they could get a flame to be greater than 10 or 11 feet in length, and if the dust was removed beyond that distance from the shot-hole, there could be no explosion of dust. But if the hole was stemmed with coal-dust, they introduced the element of danger into the hole itself, and had an extension of the flame to an extent of 50 feet. Most certainly it would appear much more simple for them to move the dust for an area of 10 feet than for 50 feet. The discussion would now be closed to-day, and would be renewed at the Annual General Meeting, two months hence.

EXCURSION TO THE HURY RESERVOIR,

IN COURSE OF CONSTRUCTION FOR

THE STOCKTON AND MIDDLESBROUGH WATER BOARD;

AND

INSPECTION OF THE WORKS FOR THE FORMATION OF THE PUDDLE TRENCH AND DAM ACROSS THE BALDER VALLEY.

TUESDAY, JUNE 30, 1885.

THIS excursion was organized at the suggestion of Mr. A. L. Steavenson, with the kind permission of the Stockton and Middlesbrough Water Board, and Messrs. Walter Scott & Co., the contractors for the works, who, with Mr. D. D. Wilson, the general manager, Mr. Yourdi, the resident engineer, and Mr. John Scott gave most valuable information respecting the works in progress, and supplied the material for the plan (Plate XXXIX.) and reports descriptive of the works. About seventy members availed themselves of the opportunity, and afterwards dined in the Schoolroom attached to the Wesleyan Chapel at Cotherstone.

A hearty vote of thanks was passed to Mr. H. Bell, Mr. W. Scott, and all those gentlemen whose kind assistance had rendered the meeting so successful.

REPORT OF MR. WILLIAM GUNN.

I have this year made two separate visits to the site of the Embankment of the Hury Reservoir. On the first occasion I made (on February 26th) a thorough examination of the puddle trench so far as it had then been excavated.

On the south side of the river I found the top cutting, 30 feet wide, to be in jointed and shattered sandstone; near the river, southwards, this sandstone was denuded and replaced by tough blue boulder clay, which,

still further south, was overlaid by gravel and also by a looser and lighter coloured boulder clay containing smaller and more rounded stones, many of them erratics. In the centre, a lower cut, 6 feet wide, was in very irregular white sandstone, near the base of which was found a coal seam of an inconstant character, in places 2 to 3 feet thick, but dividing to the northward and thinning rapidly away in the sandstone. The sandstone below the coal was thinning rapidly at the south end of the cut, as was also the whole bed, so as to appear likely to die away entirely within a comparatively short distance. Towards the river, in which direction the sandstone rapidly thickened, there were prominent joints in it ranging about north 10° west, and out of some of these came pretty strong feeders of water. Owing to very irregular deposition, the base of the sandstone suddenly and sharply dipped down to the north under the river, and there was interposed a trace of nodular ironstone between it and the thick shale bed below. A heading was being driven in the thick bedded sandstone under the river, and here the beds seemed to have a westerly dip; but this may have been only false bedding, like that in the sump which I descended, where the sandstone, owing to wedge bedding, appeared to dip away from the centre both eastward and westward. The shale bed below this sandstone has been proved in the sump to be at least 19 feet thick and of a firm water-tight character, well fitted to form the bottom of the puddle trench.

I found the top cutting on the north side of the river in strong blue boulder clay overlying a bed of shale which had been touched in several places. Several irregular beds and dishes of gravel had been found in and over this boulder clay.

The lower cut was through jointed and shattered whitish sandstone into a second shale bed below. This shale of a rather loose texture, somewhat bituminous and with thin coaly layers, near the river got firmer, and was found to be thicker towards the north end of the cut, becoming a good water-tight shale. The sandstone above was swollen out a little both above and below towards the middle of the cut, but in section was approximately level, though at the north end it appeared to have a decided dip westwards inclining to south. This second bed of shale might have served well for the bottom of the puddle trench had it not proved to be exceptionally thin and poor under the river, and especially so close to the south side, where it appeared, according to the borings made ten years ago, to be perfectly satisfactory.

On May 4th I made a further examination of the puddle trench, with which considerable progress had been made since my last visit, on the

south side the trench being cut 60 feet further southwards. Unfortunately the day was wet, and a good deal of surface water was running into the cut, loosening the rock at the heading, and causing frequent falls, so as to render a thorough examination somewhat dangerous. But there can be no doubt of there existing a slight trouble or disturbance of the beds, which consist of shales and strong bind or thin shaly sandstones, accompanied by the seam of coal before mentioned. These beds are tilted up so as to dip steeply northwards. However, there may be little or no actual break, but only a sharp twist or roll in the beds, which may soon be passed through and found to be again approximately horizontal. This will soon be proved probably by further excavation which is necessary to prove the fault if any exist. The disturbance seems to yield some water. Above these tilted-up beds was found a mass of glacial gravel, containing in its lower parts angular masses of transported or broken shale and sandstone, the whole being capped by stiff blue boulder clay. Doubtless we have here the old pre-glacial bed of the river, for the glacial deposits are in this place at a considerably lower level than they are beneath the present bed of the Balder.

Owing to a breakdown in the pumping machinery, the cutting on the north side of the river was flooded, so that I was prevented from examining it.

I have, however, seen the sections which have been plotted by Mr. Yourdi of the strata exposed in the heading under the river, and in the trench which has been opened out 150 feet north of the river.

It appears certain from this information, and from borings made still further northwards, that the two beds of sandstone are both thinning in a northerly direction, and the shales below them are thickening, so that it will soon be quite safe and advisable to raise by steps the bottom of the puddle trench from the lower bed of shale to the middle shale, and again from that to the upper bed of shale, which will make a good bottom for the trench on this north side beneath all the glacial deposits.

Thus the only doubtful place is the end of the trench on the south side, and this will probably show itself satisfactory. After getting through the *trouble* in the shale and sandstone, it will also be necessary to cut out completely the dish of gravel, &c., constituting the old pre-glacial valley, beyond which it will probably be found there is tough blue boulder clay as on the north side of the hollow.

(Signed) W. GUNN.

To JAS. MANSERGH, ESQ., C.E.

PAPER PREPARED AND READ BY MR. W. H. C. STANFORD (MR. MANSERGH'S CHIEF ASSISTANT), ON THE OCCASION OF CUTTING THE FIRST SOD OF THE HURY RESERVOIR, 14TH AUGUST, 1884.

SEE PLATE XXXIX.

The Hury Reservoir, which is the work just inaugurated, will contain, in round numbers, 900 millions of gallons, and will be formed by constructing an embankment across the valley of the Balder, and when filled will have a water area of about 160 acres.

I will describe the works in the order they will have to be carried out.

The first operation is to remove the soil from the surface and place it on one side for re-instalment. This, you have seen, has already been done, our worthy Chairman having taken his share in this portion of the work.

The next thing the engineer has to consider, unless he wishes to court disaster, is the provision for flood waters during the construction of the embankment.

In the case before us the amount to be dealt with is that flowing off the whole drainage area of over 10,000 acres, and from experience on similar gathering grounds, it has been considered prudent to make provision for the passage of 5,000 cubic feet per second, or about 2,000 times the minimum flow in times of extreme drought.

CULVERT.—The culvert which this possible flood will pass, and of which the trench has already been partly excavated, will be 540 feet long, 15 feet high, and 15 feet wide, the invert and sides being struck to a radius of 15 feet, and the arch semi-circular.

To avoid cutting bricks the angles formed by the sides and invert will be rounded to an internal radius of 4 feet 4 inches.

The inside area of the culvert will be 174 square feet, and should the maximum flood occur the water will have to pass through it with a velocity of nearly 29 feet per second.

In order that the water may acquire this velocity, the upper end will be bell-mouthed to a width of 25 feet and height of 20 feet, and a concrete wall will be constructed to turn the water into it. The top of this wall will be 25 feet above the invert of the inlet end.

This culvert will be of brickwork in cement, surrounded with Portland cement concrete.

The two inner rings of brickwork will be of blue Staffordshire bricks, the remainder of wire-cut bricks from the Normanby Brick and Tile Works.

In crossing the puddle wall, a shoe will be formed for the reception of the puddle above.

At about 100 feet beyond the puddle wall the valve shaft will be placed, and, 24 feet further, provision will be made for the insertion of the stop, on the completion of the works.

For a length of about 150 feet, that is from the inside of the culvert to the stop, a ring of asphalte will be placed between the brickwork and concrete.

I must here remark that the construction of a culvert of these dimensions was not originally contemplated, it being the intention of the Water Board to execute the Blackton Reservoir at the same time as the Hury Reservoir; the former to be used as a compensation reservoir, and the latter for the storage of comparatively bright waters from the Balder and the neighbouring Lune valley for supply only.

Had this been done, it was intended to construct on the south side of the Hury Reservoir a channel of sufficient discharging capacity to convey all flood water past the Hury Reservoir.

This would have been the first work executed in that case, and it would have relieved the Hury embankment of all flood water, except that draining into the Hury Reservoir on the north side.

The culvert required to deal with this limited amount would have been of insignificant dimensions.

TRENCH.—The next operation is the excavation of the trench in which the impermeable web of the embankment, whether concrete or puddle, is to be placed. It is, of course, necessary that this should be carried down to water-tight strata, if possible, into good shale or clay. It is also essential that the water, in seeking to find its way through the fissures of loose rock, should not have exposed to its action such a material as puddle, which would be rapidly washed away.

From the borings already made, we expect to find a layer of loose rock over a considerable length at the deepest part of the embankment. We shall know more about this when the trench is got out.

The intention at present is to form a shoe of concrete, resting on this rock, having a central tongue 6 feet in thickness, which will be carried down to the shale below. The concrete shoe will be formed so that the puddle wall above will wedge into it, and so make water-tight contact by the tendency of its own weight.

PUDDLE WALL.—The top of the puddle wall will be 4 feet 6 inches above top water level, and at this level it will be 6 feet in thickness.

The puddle will have a batter on either side of 1 inch to a foot. It will, therefore, be about 22 feet thick at ground level in the bottom of the valley.

EMBANKMENT.—The top of the embankment will be about 95 feet above the bed of the Balder and 20 feet wide, with the outer slope of $2\frac{1}{2}$ to 1 for a distance of 100 feet from the top. There will then be a level benching of 20 feet wide, and the slope will be continued at 3 to 1 for a length of 140 feet, where it will be carried horizontally to the outer toe.

The inner slope at the top will be 3 to 1 for a length of 135 feet from top water, then 4 to 1 for a length of 40 feet, then 5 to 1 for a length of 40 feet, then horizontal to the inner toe. The total width at the bottom will be above 550 feet.

The portion of the embankment nearest the puddle wall, having a width at top, including puddle, of 20 feet, and battering on either side 6 inches to the foot, or $\frac{1}{2}$ to 1, will be of specially selected material.

The seat of the embankment will be specially prepared by benching all over, and the portion outside the puddle trench drained with glazed socket pipes.

The embankment and puddle wall will be carried up together in 6-inch layers, and thoroughly rolled with steam rollers.

The outside slopes of the embankment will be soiled 9 inches deep; and the lower part of the inner slope will be beached with broken stone, 3 feet thick.

The upper portion of the inner slope will be pitched to a depth of 20 feet below top water-line, with square hammer-dressed pitching, 18 inches thick, on 18 inches of broken stone.

The top of the embankment will be finished on the inside with a stone wall 3 feet high, and on the outer side with a scabbled curb. The roadway between the wall and the curb will be metalled and steam rolled.

VALVE TOWER.—The valve tower will be 7 feet 6 inches internal diameter, lined with brickwork. The brickwork below the ground level of made embankment will be surrounded with concrete, and above that level will be faced with ashlar.

The valve house on the top of valve tower, will be of ashlar of bold ornamental design. Access to it will be given by means of a wrought-iron lattice girder foot-bridge from the top of the embankment.

In the valve well provision will be made for drawing off the water at varying depths, when the time comes to make use of the Hury Reservoir

for its original purpose of supply. The water will be drawn off through a central pipe, 2 feet in diameter. This pipe will also be made use of to form the central support of a cast-iron spiral staircase, by means of which access will be given to all the valves, and to the culvert below.

OVERFLOW.—The overflow will be somewhat of the shape of a spear head on plan. The lip will have a total length of about 350 feet. The lip will be of tooled ashlar on concrete foundation.

The wing walls of bell-mouth to bye-wash, and the wall forming the face of the embankment on the south side of the bye-wash, will be of concrete, faced with ashlar.

The puddle wall will not be carried under the bye-wash, but will be continued along the back of the north wing wall of bell-mouth, and between the return wall forming the dolphin head.

BYE-WASH.—The floor of bye-wash will be formed of tooled ashlar ribs, the pockets being filled in with five to one concrete. The side walls will be of ashlar backed with concrete. The bye-wash will be 50 feet wide at the top of the wall, and will have a total length of 770 feet. The invert will have a camber of 2 feet in the middle, and the side walls will be generally 5 feet high. The roadway on top of bye-wash will be carried over the bye-wash by means of a wrought-iron lattice girder bridge.

The toe of the bye-wash will also protect the foundations of the outlet from the culvert, and the fish-pass will be formed of a massive wall of concrete, taken well into the solid rock. This toe will be struck with a radius of about 65 feet 6 inches, the centre being at the point of intersection of the centre lines of the bye-wash and culvert.

FISH-PASS.—The fish-pass, which has been slightly modified from the original design, to meet the views of Professor Huxley, will be carried, for the greater part of its length, alongside the bye-wash. It will be 5 feet wide, and 4 feet 6 inches deep on the average. The fall in the steepest portion will be the same as the bye-wash, which is 1 in 5·2. The drops will be of 15 inches, and they will be 6 feet 6 inches apart, centre to centre.

The inlet to fish-pass from the reservoir will be provided with an adjustable sluice, by means of which the passage of the fish will be possible within certain limits, at varying levels of the water in the reservoir.

BULKHEAD.—When the works already described are completed, and before the reservoir can be filled, it will be necessary to put a stopper in the 15 feet culvert. It is intended to provide through this stopper three permanent outlet pipes of 18 inches diameter, and two temporary outlets of 24 inches diameter, the latter to be closed permanently on the

completion of the work. The object of the temporary outlets is to provide, as much as possible, for the passage of the water during the construction of the stop itself, so that the green work shall not be subjected to too great a strain.

The face of the stop will be formed of cast-iron plates, to which the outlet pipes will be made good, sound, and water-tight. The cast-iron plates will be fixed to four massive cast-iron girders, which will be bolted to a cast-iron ring built into the brickwork when the culvert is in construction.

When the pipes are all connected, and the valves and flaps commanding them are in position, the pipes will be surrounded with concrete, well rammed into every interstice, and the culvert, for a length of about 18 feet behind the cast-iron plates, will be completely filled with a mass of solid concrete. The temporary pipes, which will have bell-mouth inlets, will then be stopped by dropping spherical wood balls into them, and blank flanges will be bolted on their outlets. The water may then be allowed to rise.

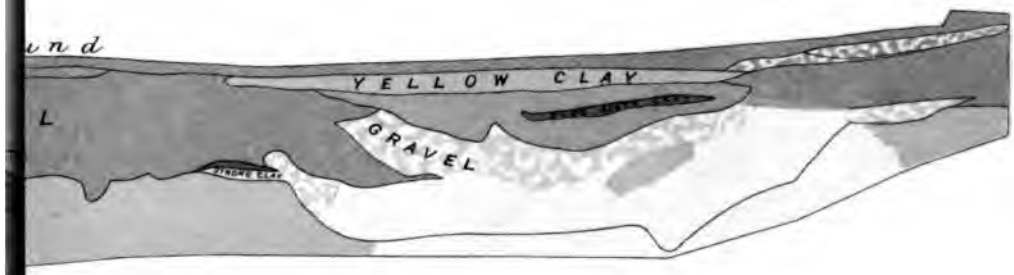
In addition to the three permanent 18-inch outlets through the stop, there will be three more at different levels, of the same diameter, in the valve tower. All these outlets will be commanded by double geared sluice valves, worked from the valve house at the top, each valve having an indicator, showing whether it is open or shut. On the outside of these inlets they will be provided with water-tight flaps, worked also by indicating lifting gear in the valve house. All the outlet pipes will be provided with air cocks and charging pipe, tapped into the outlet pipe just above the valve. The charging pipe to be commanded by a cock to each outlet.

Gauge-Basin.—At the outlet end of the 15 feet culvert a gauge-basin will be constructed, to enable the parties interested to test the amount of the compensation water in accordance with the Act. This basin will not be completed until the culvert has fulfilled its temporary purpose of discharging flood water, and when its dimensions may be reduced without danger. It is intended to throw a dam across the lower end of the culvert, which will back up the water to about 5 feet 6 inches above the invert. Below this the water will flow into a tank of known capacity, passing over a gauge-plate at its lower end.

Means will be provided for emptying this tank, and of suddenly closing the outlet when the tank is empty. The time taken to fill a given space will then be noted, and the actual flow gauged without interference with the normal conditions.

SECTION A. A.

Proceedings N° E.I. of M.M.E. 1884-85



Andrew Reid, Newcastle.

PROCEEDINGS.

ANNUAL GENERAL MEETING, SATURDAY, AUGUST 1ST, 1885, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

JOHN DAGLISH, ESQ., PRESIDENT, IN THE CHAIR.

MESSRS. S. C. Crone, A. M. Potter, and G. A. Lebour, were appointed scrutineers to examine the voting papers for the election of Officers for the year 1885–86.

The SECRETARY read the minutes of the last general meeting, and reported the proceedings of the Council.

The annual reports of the Council and Finance Committee were also read.

The following gentleman was elected, having been previously nominated :—

ASSOCIATE MEMBER—

Mr. J. H. ARMSTRONG, Accountant, St. Nicholas' Chambers, Newcastle-upon-Tyne.

The following gentleman was nominated for election :—

ASSOCIATE MEMBER—

Mr. G. R. PEARSON, 10, Bensham Crescent, Gateshead-on-Tyne.

The following translation of the "New Mining Regulations of Belgium," by Mr. M. Walton Brown, was considered as read :—

NEW MINING REGULATIONS OF BELGIUM.

APRIL 28, 1884.

TRANSLATED BY M. WALTON BROWN.

IN July, 1879, the King of the Belgians appointed a Commission, consisting of official representatives and mine-owners, for the purpose of revising and consolidating the regulations of mines in that country.

Many of the previously-ordered regulations and rules had fallen into disuse, others were inapplicable owing to progress in the working of mines, and others had been virtually abrogated by more recent enactments.

The following regulations are the results of fifty-nine meetings of the Commission. These regulations, while strictly guarding the operations of mining from ordinary accidents, afford the mine-owners, within limits imposed by prudence, a certain amount of liberty favourable to the development of one of the principal branches of the national industry, and give every protection as regards the lives of the miners.

PART I.—RULES TO BE OBSERVED TO INSURE THE SAFETY OF THE ORDINARY WORKING OF MINES.

CHAPTER I.—ON THE KEEPING OF PLANS OF MINES.

1.—All lessees of mines must keep, separately for each seam or deposit, a plan and a register showing the monthly progress of the workings, the condition and the nature of the strata, together with memoranda of such circumstances which it may be useful to note, as being of interest to the working of the mine and the safety of the workmen.

Upon this plan shall be shown all dwelling houses and buildings, the principal means of communication by land and by water, and the boundaries of the royalty; it shall also record the position and the altitude, with regard to the sea-level, of the mouths of pits and of day drifts.

Nevertheless, a special plan of the surface shall be required when this information cannot be given upon the plans of the underground workings without prejudice to the clearness or the fluent perusal of these plans.

The plans required in the present rule shall be drawn to the scale of $\frac{1}{1000}$th,* in conformity with the ministerial instructions annexed to the present regulations.

The plans of metalliferous mines may be drawn to a larger scale.

2.—The drafts of the plans and registers of progress shall be deposited at the mine, or at the office of the management of the workings of the company, if it is not too distant; one copy of these plans and of these registers shall be forwarded to the "Administration des Mines;" it shall be exchanged, in the course of the first six months of each year, for another copy duly completed.

3.—When any working in a mine is intended to be abandoned, the manager of the mine is required to give written notice of it to the Inspector of Mines, before the workings become inaccessible.

If the manager of the mine omits the performance of this notice, the "Députation Permanente," upon the recommendation of the Inspector, may direct that the workings shall be made accessible at the cost of the lessee.

4.—When the plans and registers shall not have been kept as required by rule 1 or shall not have been supplied within the prescribed time, the Inspectors of Mines shall report the fact to the "Autorité Provinciale," which shall cause them to be made officially at the cost of the lessee, without prejudice to the penalties mentioned in rule 90.

5.—The plans required by the preceding rules shall be signed by the lessees or their agents.

CHAPTER II.—OF SHAFTS.

6.—Every mine shall have at least two distinct outlets accessible, at all times, to the workmen employed in the several parts of the mine.

7.—The top opening of a pit, where ladders are used as a means of egress, must be placed outside of the principal buildings of the mine.

8.—The tops of all working pits shall be provided with gates or trap-doors, placed so as to avoid all danger to persons passing and to the men at work.

Similar precautions shall be adopted at the several levels of admittance, to prevent the workmen from falling into the shafts, and the immersion of the cages or tubs containing workmen into the water which may be found in the sump.

9.—The tops of shafts specially appropriated to the maintenance of

* 1·26 chains to an inch.—M. W. B.

galleries near to the surface shall be surrounded with a wall at least 10 feet in height. The access to these shafts shall be prevented by a locked door. The doors made at the surface, into the ventilating tubes or chimneys, shall also be locked.

10.—All shafts temporarily abandoned shall be immediately covered over with battens or by a stone arch of sufficient strength.

In case of definite abandonment, the manager of the mine shall give one month's previous notice to the "Députation Permanente du Conseil Provincial" who, upon the advice of the Inspector of Mines, will prescribe the provisions that they may consider necessary for the safety of persons and property.

CHAPTER III.—OF THE DESCENT AND ASCENT OF WORKMEN.

11.—The descent and ascent of workmen shall be made by means of engines or apparatus conveniently placed, working with regularity, maintained with care and in accordance with the following rules or regulations.

12.—Ladders shall be inclined at an angle which never exceeds 80 degrees.

13.—The use of ropes, for the transport of workmen in the shafts, is subordinate to the following conditions:

1° The cages shall be, as far as possible, constructed so as to prevent the workmen from falling out and to protect them under cover from stones or other missiles which may be detached from the sides of the shafts or fall from the surface;

If tubs are used for the transport of the workmen, the latter shall be held therein by means of safety straps and protected by a cover, against the fall of heavy bodies;

2° The number of workmen allowed to ride at one time in the cages or in the tubs, as well as the average speed of winding, shall be fixed by the manager of the mine and be notified by him, to the Inspector of Mines;

The cage or tub shall not receive any additional load when the workmen who are about to ride in it are of the number decided on;

On the departure or arrival of the cages or tubs, the engine shall be worked with slowness and precaution; the same care shall be observed at the meetings of the cages or tubs, when the pit or compartment in which they run is not divided;

3° At a certain height above the top of the pit, the guides shall be drawn together and safety catches inserted, to prevent the cages accidentally reaching the pulleys and falling back into the pit;

In the absence of the guides being drawn together, they shall be furnished with some system of self-acting brakes;*

4° The winding-engine shall be provided with a brake applied to the shaft of the rolls or drums, and placed in such a manner that the engineman may work it with ease, without leaving his seat;

5° The winding-engine shall be also provided with an indicator showing the position of the cages in the pits; and an automatic bell shall signal their arrival at bank;

The manager of the mine shall adopt a code of signals to be given to the engineman for all the various operations required;

6° Necessary arrangements shall be made by the manager of the mine, in case of accident to the winding gear, to draw any workmen who may happen to be riding in the cages or tubs;

7° The manager of the mine shall adopt all measures requisite to insure good order during the descent and ascent of the workmen.

14.—The manager of the mine shall cause to be made at least once in every week, an inspection of the shaft and of all the tackle used for the descent and the ascent of workmen.

15.—A special register shall be kept at the mine, recording the date of the laying on, of the repairs and of the removal of each rope; and in it are to be recorded the results of the periodical inspections made by the manager of the mine, independently of the ordinary inspections mentioned in the preceding rule.

CHAPTER IV.—VENTILATION, LIGHTING AND USE OF EXPLOSIVES.

16.—The mines are classed, as regards the rules for regulating the ventilation, lighting and use of explosives, into fiery mines and non-fiery mines.

The designation of fiery mines shall be determined, for each mine, by the "Députation Permanente du Conseil Provincial," upon the report of the Inspector of Mines, after the lessee's observations have been considered.

* These self-acting brakes consist of a combination of levers which apply a steam brake to the engine and close the steam valve as soon as the cage passes a certain point in the guides.—M. W. B.

DIVISION I.—REGULATIONS FOR THE VENTILATION OF MINES IN GENERAL.

17.—In all underground workings, all places accessible to workmen shall be rendered wholesome by a sufficient current of pure air.

The velocity of this current and the sectional area of the galleries shall be especially regulated in proportion to the number of workmen, to the extent of the workings and to the gaseous condition of the mine.

The air-ways shall be easily accessible in every part of their length.

18.—The ventilation shall be produced by some efficient means, regular, continuous and exempt from all danger.

19.—Every current of air vitiated by a mixture of deleterious or inflammable gases, so as to form a source of danger to the health or safety of the workmen, shall be carefully led from any working place and travelling roads.

The extent of the working places shall be limited, if necessary, so as to preserve the men working in the return current, from the harmful effects of too great an alteration of the air.

20.—The pack-walls used for sustaining the roof and for separating the intake or wagon-ways from the corresponding return air-ways, shall be built as close and maintained as impermeable as possible.

21.—The pack-walls shall be advanced at all times to a convenient distance from the working face, so that the air current shall be always sufficiently active to prevent dangerous gases accumulating there; at the same time too great an acceleration of the velocity of the current shall be avoided.

22.—The workings shall be arranged so as to avoid as much as possible the use of doors for directing or dividing the air current. Every door used for the division of the ventilation shall be arranged so as to insure the passage of a volume of air in proportion to the requirements.

The use of multiple doors, conveniently situated, shall be obligatory in ways where they must be frequently opened for the service of the mine.

23.—Abandoned and unventilated roads and workings shall be made inaccessible to workmen.

DIVISION II.—CONCERNING THE REGULATION OF FIERY MINES.

24.—Fiery mines are divided into three classes:

1° Mines with little gas;

2° Fiery mines;

3° Mines subject to sudden issues of gas.

25.—This division, which shall be made for every mine, shall be determined by the "Députation Permanente du Conseil Provincial," upon the report of the Inspector of Mines, after the lessee's observations have been considered.

Article 1.—*Rules to be observed in all Fiery Mines.*

26.—The workings shall as far as possible, be made by lifts taken successively in descending order.

27.—Ventilation by descending current along the working faces is forbidden.

28.—The exit of the air from the mine shall be made by a pit separated from the other pits by a sufficient thickness of solid rock.

29.—All necessary precautions shall be taken, on the surface, to prevent the gas issuing from the upcast shaft approaching any fire.

30.—The intake and return air-ways shall be separated by pillars sufficiently solid to resist an explosion of gas and sufficiently tight not to allow too great a quantity of air to be lost.

31.—"Royons,"* tubes, "canars" or "kernés,"† shall only be employed for the ventilation of preparatory work or winning places.

Article 2.—*Special Rules to be observed in Fiery Mines of the Second and Third Classes.*

32.—Subject to any exceptions which may be allowed by the competent authorities, workings in the seam other than those of preparation and of exploration shall be arranged so as not to compel the downward direction of air more or less charged with inflammable gas.

33.—Before commencing any preparatory or exploring workings, in either stone or coal, ventilated by means of a descending air current, the manager is required to give notice to the Inspector of Mines and to acquaint him with the arrangements intended to be taken so as to ensure the ventilation of the working places.

34.—Air shafts shall not, without special permission, contain any machinery or apparatus which would interfere with the ventilation.

35.—No winning place or any preparation for working in the seam shall be commenced, before the upcast shaft has reached the depth at which this working is to be made.

36.—Cross-measure drifts shall only be made at a new level, after a communication has been made between the downcast and upcast pits.

* "Royons" are small airways and ladderways made in the walling of a shaft.—M. W. B.

† "Canars" or "kernés" are a kind of air boxes for taking air to or from any working place.—M. W. B.

Article 3.—Special Rules to be observed in Fiery Mines of the Third Class.

37.—All drifts in approaching coal-seams known to be subject to sudden outbursts of gas, shall be ventilated by an air current coming directly from the downcast pit and returning immediately to the upcast shaft, as directly as possible, without passing at any time across any working places.

The gallery used for this return air-way must be solidly constructed and maintained in good condition.

38.—When, in the sinking of a pit or driving of a gallery, the proximity of a seam liable to sudden outbursts is expected, care should be taken:

1° To make boreholes passing completely through the seam;

2° To wait afterwards, at least two days, before breaking completely into it.

39.—All coal working, in a seam liable to sudden outbursts of gas, must be systematically preceded by boreholes to facilitate the issue of the gas.

40.—The number, dimensions and direction of the boreholes provided for by the two preceding rules, shall be determined by the manager of the mine, according to local circumstances, taking into consideration, both the nature of the rocks to be passed through, and the nature, thickness and hardness of the seam to be worked.

41.—The use of naked lights is forbidden in the buildings covering the different shafts of the colliery as well as in the approaches to the shafts.

42.—There shall be no roof above the pulley frames at the winding pit. The pulley frames shall be constructed of incombustible materials.

DIVISION III.—LIGHTING OF FIERY MINES.

43.—The use of safety-lamps burning pure vegetable oil is obligatory for the lighting of fiery mines. (See page 132, and Plate XIX. Vol. XXIX.)

44.—With the exceptions hereafter mentioned, the Mueseler type of lamp, constructed in accordance with the official instructions attached to the present regulations (Drawing No. 1) shall be used, to the exclusion of all other appliances for lighting, in mines of the second and of the third classes. The variations of dimensions and of form, mentioned in the aforesaid instructions (Drawing No. 2), are however allowed. (See Plate XIX. Vol. XXIX.)

"Chefs-mineurs" or "porions,"* "surveillants,"† workmen employed in the repairing of the pits and the "désancreurs de cheminées"‡ are authorised to use:

1° The porions' Mueseler lamp, without horizontal gauze or chimney, the cylindrical cover of which resting on the glass shall consist of a double gauze of iron wire of $\frac{1}{3}$ millimetre§ diameter, with 144 meshes to the square centimetre.‖

2° The Mueseler-Godin lamp, with internal glass simply supported by a non-detaching appendage, as is shown in the aforesaid instructions (Drawing No. 3). (See Plate XIX. Vol. XXIX.)

Mineurs-surveillants, the chef boute-feu des avaleresses (chief or head workman of the shift, who usually takes the place of the mineur-surveillant) may use Davy lamps.

Large Mueseler lamps, constructed in accordance with the instructions attached to the present regulations (Drawing No. 4), can be used for the fixed lights at the pit bottom. (See Plate XX. Vol. XXIX.)

45.—The use of the porions' Mueseler lamp, as described in the preceding rule, is authorised in fiery mines of the first class.

46.—Safety-lamps must be made to lock and be kept at the colliery. Lampmen appointed by the manager of the mine will ascertain that the lamps are in conformity to the type allowed; they are required moreover to inspect, clean and keep them in good condition.

These men are included amongst those who have charge of the workmen.

47.—Just before the descent, a lamp is handed to each workman and he is required to see for himself that it is properly locked and in good condition. From the time of receiving his lamp the workman is responsible for it. Every workman whose lamp may be damaged is required to extinguish it at once.

48.—Opening the lamps in the workings is strictly forbidden, and no man is allowed to carry with him, or make use of, any instrument capable of opening them.

49.—Lamps that may have been put out in the mines of the two first classes shall be sent out-bye either to the surface, or to the bottom of

* "Chefs-mineurs" or "porions" correspond to the overmen of the North of England.—M. W. B.

† "Surveillants" are to some extent similar to the deputies of the North of England.—M. W. B.

‡ The "désancreurs de cheminées" attend to the staples between the seams.

§ About $\frac{1}{84}$ inch.—M. W. B.

‖ About 929 meshes to the square inch.—M. W. B.

the downcast pit, where they shall be examined, re-lighted and re-locked by a workman appointed for this purpose, who alone shall be in possession of a key.

Lamps that may have been put out in mines of the third class shall only be re-lighted in the lamp room at bank.

50.—Smoking or the carrying of a pipe, a match, flint and steel, or any article capable of producing a light, is forbidden in fiery mines.

51.—When fire-damp is found at the face or in a gallery, in sufficient quantity to produce a sustained elongation of the flame of the lamp, work must be immediately suspended there, until the danger has passed away.

DIVISION IV.—USE OF EXPLOSIVES.

Article 1.—*Regulations applying to all Mines.*

A.—Carriage and Storage.

52.—Explosive bodies may only be taken into mines or into buildings in their immediate vicinity, by the instructions of the manager of the mine or his representative, and in conformity with special precautions which he may order to be taken.

Explosives may only be taken into the mine in the form of cartridges and in carefully closed boxes or bags.

53.—Powder, dynamite and detonators must be isolated from each other and kept in separate boxes or bags.

54.—Only the number of cartridges expected to be required during the shift shall be taken into each working place.

55.—Explosives, not intended for immediate use, shall not be left in the workings of the mine.

56.—Until the time of being used, cartridges and fuzes for blasting shall be stored in a safe place, appointed by the chef-mineur.

B.—Use.

57.—Instruments of wood, zinc, or copper, shall alone be used to introduce the cartridge into the shot-holes and to stem them.

The material used for stemming must not be capable of producing sparks.

58.—No shot missing fire shall be unstemmed.

Article 2.—*Rules to be Observed in Fiery Mines.*

59.—Unless previously authorised, the use of explosives is prohibited:

1° In all fiery mines, for blasting the coal;

2° In mines of the second and third classes:

A. For driving the upper return air-way;

B. For exploring places in seams ventilated by a descending air current;

C. For all stone drifts, when it is expected that these workings are about to hole into goaf and generally any working in which gas might be accumulated;

3° In mines of the third class:

A. In stone drifts, when they are about to cut a seam subject to sudden outbursts of gas;

B. In seams subject to sudden outbursts of gas, for making height and working on stone in places which are not ventilated by a current of fresh air which has not passed over any place in actual course of working.

60.—The use of explosives is subject to the following rules:

1° No substance shall be used for their ignition capable of burning with flame.

2° Shots shall only be fired at times when there are comparatively few workmen employed in the adjacent workings, and after ascertaining, by an examination of the flame of the lamp, that there is no gas in the surrounding air.

This examination shall be made, before the ignition of each shot or of each group of shots, by a competent person appointed for the purpose by the manager of the mine.

61.—In mines of the second and third classes, only one shot may be ignited at a time in each working place, unless the ignition of the shots be simultaneously effected by electricity.

CHAPTER V.—DANGEROUS ACCUMULATIONS OF WATER.

62.—Lessees of mines are required to carefully collect all information relative to the position, extent and depth of old workings and natural accumulations of water (water-bearing faults and fissures) which may exist within the area or in the neighbourhood of their royalties.

63.—Boring in the coal or in the stone is compulsory, whenever there is cause to suspect the existence of accumulations of water in the vicinity of the working places.

The number, length and direction of the boreholes shall be determined by the manager of the mine, according to local circumstances, taking into special consideration the thickness and the composition of the beds, the

hardness of the coal and rocks to be bored, the disposition of the working places and the presumed pressure of the accumulation of water it is expected may be encountered.

64.—During the continuation of the boring, the workmen shall always have within their reach the necessary appliances for immediately closing up the boreholes, if required.

65.—Before drawing off an accumulation of water, the manager of the mine shall adopt every necessary precaution for the protection of the workmen from any accident which might result from this operation.

He shall record, in the register which is hereafter directed to be kept by rule 67, the precautionary directions which had been decided upon.

66.—The persons responsible for the supervision of the work of the borers shall be designated in the register of the workmen; and they shall report the condition of the boreholes to the chef-mineur, before the arrival of each shift.

67.—A register shall be kept recording the position of the boreholes in each working place.

CHAPTER VI.—CONTROL OF THE WORKMEN.

DIVISION I.—DISCIPLINE OF THE WORKMEN IN ALL MINES.

68.—A daily register shall be kept at every mine of the workmen employed in the workings.

69.—The descent or working in mines of boys under 12 years of age and of girls under 14 years of age is prohibited.

70.—No person shall enter or be admitted into the mine when intoxicated or suffering from any sickness or infirmity which may endanger his life. No person unacquainted with the working of mines shall be allowed to enter without the permission of the manager or without being accompanied by an experienced workman.

71.—Every workman who, by insubordination or disobedience, shall have offended against the rules established by the manager of the mine for the safety of workmen and property, shall be prosecuted and punished, according to the gravity of the circumstances, pursuant to the provisions of the present rules, without prejudice to the penalties which he may have incurred under the articles of the Penal Code, commencing from No. 418.

The rules shall be drawn up as special rules, which shall be submitted for the approval of the "Députation Permanente" and the Inspectors of Mines.

DIVISION II.—SPECIAL EXAMINATION OF THE WORKINGS IN FIERY MINES.

72.—There shall be, for each part of a fiery mine, a chef-mineur (chef-porion or overman) charged with the daily supervision of the ventilation, lighting, and workings which are carried on with the assistance of powder and of other explosives.

The chef-mineur shall be assisted in the performance of his duties, by such a number of sous-chefs (porions) and of surveillants as may be required from the extent of the workings, the nature and the quantity of the gas which is given off and the amount of safety afforded by the system of ventilation.

73.—The chefs-mineurs, sous-chefs, and surveillants shall be so nominated, by the manager of the mine, in the register of workmen.

They shall not in any case be interested in the carrying out of the work which they are appointed to inspect.

74.—Under the charge of the chefs-mineurs and sous-chefs, the surveillants in each part of the mine assigned to them, are directed:

A. Not to allow any shift of men or portion thereof to have access to the workings, especially after holidays or stoppages, until they are certain that the air is pure, that the ventilation is sufficiently active, that all is in order and that no apparent cause of danger to the workmen exists; to watch the execution of the precautions ordered by the regulations concerning the use of explosives; to carefully examine the air-ways and to ensure their maintenance in good condition;

B. To keep, during the course of their shift, a strict watch in the face and in the travelling roads on the mode of using the lamps, the hewing and putting the products of the mine, the working of the doors, and in short on everything material to the safety of the mine, so far as regards ventilation and lighting;

C. To report, for prosecution and punishment according to the gravity of the case, all persons guilty of breaches of the rules for the safety of the mine and the discipline of the miners; to act in the same way with respect to all workmen who shall be found carrying a pipe, matches, flint and steel, or any article capable of producing light, in the workings where the use of safety lamps is compulsory;

D. To stop working, and cautiously direct the withdrawal of the workmen, in the case provided for by rule 51, or whenever any check occurs to the ordinary amount of ventilation.

CHAPTER VII.—TEMPORARY ARRANGEMENTS.

75.—The "Députations Permanentes des Conseils Provinciaux" may give time or conditional exemption from the strict enforcement of the preceding regulations, when requested.

The "Ministre de l'Intérieur" will decide any appeals which may arise from the decisions of the "Députations Permanentes."

PART II.—SPECIAL ARRANGEMENTS FOR THE PREVENTION OF ACCIDENTS.

76.—When the safety of the mines or of the workmen is endangered by any cause whatever, the lessee of the mine or his agent is required to give immediate notice to the Inspector of Mines.

The Inspector shall proceed to the mine, without delay, to arrange with the manager as to the means to be adopted for avoiding the danger.

When the lessee of the mine or the manager refuses to carry out the means deemed requisite by the Inspector, the latter shall report it to the Governor of the Province and send him a copy of what he considers ought to be done.

The "Députation Permanente" shall hear the lessee of the mine or his agent duly summoned, and shall order the necessary arrangements to be made by a decree, which shall be submitted to the "Ministre de l'Intérieur," for approval, if there is cause, after having taken the opinion of the "Conseil des Mines." If the Inspector, in his report, states that the case is urgent, the "Députation Permanente" shall order its decree to be provisionally carried out, without being compelled previously to hear the lessee of the mine.

77.—When an Inspector in examining a mine, discovers a source of imminent danger, he shall make, upon his own responsibility, the necessary orders to the local authorities to be carried out at once, in the way he may deem necessary, as in the case of a highway, when there is imminent danger of the fall of a building.

PART III.—RULES TO BE FOLLOWED ON THE OCCURRENCE OF ACCIDENTS.

78.—Every accident occurring in mines or in the buildings immediately connected therewith, in consequence of which one or more persons have been killed or severely injured, shall be immediately reported by the lessees to the Inspector of Mines.

Severe wounds include all injuries which are of such a nature as to cause the death or to interfere with the ordinary employment of the workman.

79.—A similar obligation is prescribed upon the lessees in the case where the accident compromises the safety of the workings, of the minerals, or of the buildings upon the surface.

80.—When any of the occurrences named in the two preceding regulations come to the knowledge of the Inspector of Mines, he shall, if he think proper, go to the mine, enquire into the cause and prepare a written report upon it.

He may, in case of imminent danger, make requisitions of tools, of horses and of men, and give the necessary orders for the rescue of the workmen and the safety of the mine.

These orders, and the necessary measures for averting fresh dangers, shall be carried out under the direction of the manager of the mine, subject to the control and approval of the Inspector of Mines. In case of non-agreement as to the measures to be adopted, the opinion of the Inspector of Mines shall prevail.

81.—Lessees are required to provide their mines with medicines and appliances for first aid to the injured, in conformity with the instructions which shall be issued by the "Ministre de l'Intérieur."

82.—One or more surgeons shall be attached to each mine, in proportion to its size.

83.—The lessees and managers of mines adjacent to those where an accident has occurred shall supply all the means of assistance which they have at their command, either with men, or in any other manner, subject to indemnity, if necessary, from the parties liable.

84.—When the impossibility of reaching the positions where the bodies of the workmen who have been killed in the workings has been ascertained by the Inspector of Mines, the manager of the mine is required to give notice of it to the Burgomaster or other officer of the Government, who shall prepare a written report and forward it to the "Procureur du Roi" who, with the authorisation of the Court of Justice, shall see that this certificate is annexed to the register of the état-civil.

85.—The costs of the first assistance given to injured, drowned, or suffocated workmen, and the restoration of the mine, shall be at the expense of the lessees.

86.—The Inspectors of Mines shall forward, with the least possible delay, to the "Procureur du Roi," the written reports which they shall make upon each accident.

PART IV.—GENERAL RULES.

87.—Lessees of mines shall afford every facility to the Inspectors of Mines for visiting the workings and particularly for visiting all places which may require any special examination. They shall produce, at their request, the plans and registers provided for by part I., chapter I., of the present regulations, and the register of workmen; they shall furnish every information as to the condition and progress of the workings; in examinations underground, they shall cause them to be accompanied by the managers or substitutes whose assistance may be required, in supplying the necessary information for the performance of their duties.

88.—A register shall be kept at each mine exclusively intended to receive the remarks and advice of the Inspectors of Mines.

89.—Every lessee of mines or his legal representative shall register an office in the province where the mine is situated and make this office known to the Governor.

In cases where the royalties extend over several provinces, this information shall be given to the Governor of each of these provinces.

90.—Persons committing breaches of the above regulations, even when they have not been followed by accidents, shall be prosecuted and judged in accordance with Titre X of the Law of April 21, 1810, respecting mines, quarries and works.

91.—From the date of the present decree coming into operation, all the general and provincial rules relating to the subjects which form the matter of this decree are abrogated as regards mines, with the exception of articles 3, 4, 5 and 7 of the Imperial Decree of January 3, 1813.

92.—The "Ministre de l'Intérieur" is charged with the execution of the present decree.

APPENDIX.

INSTRUCTIONS FOR CARRYING OUT THE SPECIAL REGULATIONS AS TO THE KEEPING OF PLANS AND THE LIGHTING OF MINES.

I.—PLANS.

A.—The plans of the workings required by the first rule of the general regulations shall consist of a horizontal projection, of a vertical projection and of vertical sections passing through the pits; they shall show, as exactly and as clearly as possible, the position of the workings and the condition of the seams being worked.

When, however, this result can be obtained by means of figures inscribed upon the horizontal projection, the vertical projections may be dispensed with. These figures are to indicate distances either from the level of the sea, or from the mouth of the pit whose altitude, in this case, has been determined with regard to the sea level.

The numbers of the stations and the corresponding pages of the register of progress shall be noted along the position of the drifts, pits and staples (tourets, burquins or bouxtays).

The exhausted areas shall be coloured grey; the boundaries of each year's workings shall be shown by means of a border, inside of which the date of the year in which it was worked is to be written.

B.—The paper used in the making of plans, shall have a useful area of ·90 m. × ·60 m.,* divided into squares of ·10 m.† square. Each line of the network shall have a sign (letter or figure) to facilitate, when necessary, the joining of the sheets together.

The short side of the sheets shall be parallel to the direction of the meridian used for the plotting of the plans.

C.—The registers of progress shall be kept so as to furnish, at least, the information required in the following table:

Date.	Magnetic Declination.	Commencement of Survey.	Number of Station.	Description of Gallery Measured.	Bearing of the Compass.	Degrees of Inclination.		Length of the Galleries according to			Positions of the Principal Points.
						Rising.	Falling.	Their Inclination.	The Horizontal.	The Vertical.	

Remarks.—These are relative to the composition of the strata, their condition, and faults; and to phenomena or facts which may be usefully recorded for the information of the lessee or the safety of the mine.

* 35·43 inches × 23·62 inches.—M. W. B. † 3·93 inches.—M. W. B.

II.—LIGHTING OF FIERY MINES.

I.—Drawing No. 1* shews in full size the Mueseler type of lamp.

The dimensions and forms of the essential parts of this lamp are as follow:

A. Glass: cylindrical ring furnished at its ends with metallic ring sockets, the upper socket covering the edge of the horizontal gauze:

Exterior diameter	60 mil.	(2·364 inches)
Thickness	5½ „	(·216 „)
Height, including the lower socket, at most	62 „	(2·442 „)

B. Internal chimney of thin iron: conical tube widened into a bell shape at the base:

Interior diameter at the top, at most ...	10 mil.	(·394 inches)
Interior diameter at the base, at most ...	30 „	(1·182 „)
Interior diameter at the commencement of the widening, at most	25 „	(·985 „)
Height of the part of the chimney above the horizontal gauze	90 „	(3·546 „)
Height of the part of the chimney under the horizontal gauze, comprising the widening into a bell shape at the base	27 „	(1·063 „)
Height of the widening into a bell shape at the base	6 „	(·236 „)
Distance from the base of the chimney to the top of the wick tube	22 „	(·866 „)

C. Cap or cover of wire gauze: a closed envelope of almost cylindrical form, surmounting the glass:

Height	109 mil.	(4·294 inches)

D. Wire gauzes (of the cap and of the horizontal gauze), made with wires of at least ⅓ of a millimetre ($\frac{1}{84}$th inch) in diameter and having at least 144 meshes to the square centimètre (928 meshes to the square inch).

* The drawings of these lamps are added to the Belgian Regulations, but are identical with the drawings attached to a previous law of June 17, 1876, and some of these drawings were reproduced on a smaller scale in Vol. XXIX. of the Transactions. Drawing No. 1 is Plate XIX., Fig. 1; Drawing No. 2 is not shewn; Drawing No. 3 is Plate XIX., Fig. 3; and Drawing No. 4 is Plate XX.—M. W. B.

II.—With the view of lessening the difficulties that occur in practice from the rigorous observation of the dimensions prescribed above, the following variations are allowed (see Drawing No. 2):

A. For the external diameter of the glass: 1 millimetre (·039 inch) more or less;

B. For the thickness of the sides of the glass: ½ millimetre (·019 inch) less or 2 millimetres (·078 inch) more;

C. For the length of each of the parts of the chimney measuring from the horizontal gauze,* as well as for the distance which separates the base of the chimney from the top of the wick tube: 2 millimetres (·078 inch) more or less;

D. Suppression of the widening into a bell shape at the base of the chimney: the lower diameter, in this case, not exceeding 26 millimetres (1·024 inches);

E. For the height of the wire gauze cap: 4 millimetres (·157 inch) more or less;

F. Reduction of the diameter of the wire of the gauze, to ¼ millimetre (⅛th inch), when the number of meshes attains or exceeds 225 to the square centimètre (1,451 to the square inch).

III.—Drawing No. 3 shews, in full size, the Mueseler-Godin lamp.

The instructions given under parts I. and II. apply to the dimensions and forms of the essential parts of this lamp.

IV.—Drawing No. 4 shews, to the scale of half the natural size, the Mueseler lamp, large size, for the fixed lighting of shafts.

The dimensions and forms of the essential parts of this lamp are as follow:

A. Cylindrical glass:

Interior diameter ...	60 to 70 millimetres	(2·364 ins. to 2·758 ins.)
Thickness	5½ to 8 „	(·216 „ to ·315 „)
Height, at most ...	100 „	(3·937 „)

B. Conical chimney:

Diameter at the top, at most ...	15 millimetres	(·591 inches)
Diameter at the base, at most ...	35 „	(1·379 „)

* The chimney is only limited in height above the horizontal gauze in order to facilitate the examination for fire-damp at the roof of the excavations.

Height of the part above the horizontal gauze : at least 90 millimetres (3·546 inches), when the mean of the diameters at the top and at the base does not exceed 20 millimetres (·788 inches), and 10 millimetres (·393 inches) of increase for each millimetre (·039 inches) in excess of this mean.*

Height of the part below the horizontal gauze : to be at least equal to half the distance of the said gauze from the top of the wick tube.†

C. Wire gauzes :

The same gauzes as for lamps of ordinary make.‡

* It follows that, for the maximum diameters of 15 millimetres (·591 inches) at the top and of 35 millimetres (1·379 inches) at the base, the height of the part of the chimney above the horizontal gauze should be at least 140 millimetres (5·516 inches):

$90 + (25 - 20) \times 10 = 140$ millimetres ($3{\cdot}546 + ({\cdot}985 - {\cdot}788) \times 10 = 5{\cdot}516$ inches).

† Taking the case of a lamp furnished with a glass of 100 millimetres (3·937 inches) in height and provided with a wick tube elevated 24 millimetres (·945 inches) above the lower edge of this glass, the distance from the base of the chimney to the horizontal gauze must be at least half of 76 millimetres (2·992 inches), or at least 38 millimetres (1·496 inches):

$$\frac{100-24}{2} = 38 \text{ millimetres} \left(\frac{3{\cdot}937 - {\cdot}945}{2} = 1{\cdot}496 \text{ inches} \right).$$

‡ In order to prevent the horizontal gauze of the cap becoming quickly impaired above the chimney, the latter can be furnished with a thin iron shield (see Drawing No. 4), intended to break the current of hot air a little beneath the said gauze.

The SECRETARY read the following description of the "Pieler Safety-Lamp :"—

THE PIELER LAMP, AND MODES OF INDICATING THE PRESENCE OF SMALL QUANTITIES OF FIRE-DAMP IN MINES.

By T. W. BUNNING.

The danger shown by the German experiments to accompany an admixture of a certain quantity of coal-dust in the atmosphere of a mine containing very small quantities of gas, seems to indicate the necessity of having some reliable daily record of the actual quantities of gas contained in the ordinary atmosphere of the mine, in different parts of the workings.

Herr Pieler has invented a very simple instrument for withdrawing average samples of air from the mine, over periods which can be varied at pleasure. See Plate XL.

Fig. 3, *a* and *b*, are two vessels, holding about 15 gallons each; *c* is a cock, which allows water to run from the top vessel into the bottom one through the pipe *d*, and *e* is a pipe which allows the water to run out of the bottom one when the cock *f* is opened, after the manner of a clepsydra. The cock *h* and the pipe *g* communicate with that part of the mine from which the sample of air is required to be taken.

To use the apparatus, the top cistern *a* is filled with water, the cock *f* is closed, and cocks *c* and *h* are opened. Water will then descend into the lower vessel and displace the air through the cock *h*. When *b* is full, the communication with the upper vessel is closed by the cock *c*, and the cock *f* is then opened in such a way that only a given quantity will escape, sufficient, say, to empty the lower vessel *b* in 24 hours.

It is evident that as the water is lowered in the cistern *b*, air will come in from the workings through the cock *h*, and, at the end of 24 hours, the cistern *b* will contain an average of the atmosphere that has prevailed where the opening of the pipe *g* has been inserted during that period.

For examinations of minute quantities of gas mixed with air the flame of hydrogen has been found superior to that of any other, and Fig. 2 shows an apparatus whereby hydrogen gas may be easily made.

In the inner glass cylinder *c*, is placed a bottom, full of holes, which carries the grains of the zinc filings for making the hydrogen. Weak sulphuric acid is poured inside the outer glass *d*, and the pressure of the hydrogen produced is kept back so long as the escape of the gas through the upper end is stopped by the glass cock *a*. When the gas is allowed to pass out of the cock, the sulphuric acid passes into the inner cylinder, in proportion as the gas is allowed to escape, and it is possible, by regulating the cock, to get an even production of gas.

Fig. 4 shows the apparatus for utilising the two instruments already described. *a* is a glass cylinder, standing upon a wooden stand *f*; an inner pipe *e* communicates with the cock *a* on the top of the apparatus for making the hydrogen, shown in Fig. 2. The cock *h* and pipe *i* communicate with the cock *h* and pipe *g* of the cistern shown in Fig. 3, so that when water is passed out of the cistern *a* into the bottom cistern *b* by means of cock *c*, the displaced air taken from the pit is passed through the pipe *i* into the receiver *d*, which surrounds the pipe *e*, so as also to surround the flame, at the top of pipe *e*, when the gas from the hydrogen is turned on. The flame of the hydrogen is therefore surrounded by the air taken from the pit. *c* is a little conical chimney, or shield, which is moved up and down by means of the screw *b*.

The glass cylinder *a* is used in order to shut off the flame from the outside atmosphere. It is not necessary to have this cylinder, as the flame can be seen quite well, or even better, without it, on account of the steaming of the glass; but, at the same time, much of the sharpness of the appearances is lost in the free air.

As this apparatus can only be used in the laboratory, the Pieler lamp (Fig. 1) is proposed as the best substitute for examining the air in the pit. It is composed of the usual receptacle for the burning medium *a* (which, in this case, is pure alcohol—C_2H_6O) The lamp is made very carefully, so that no vapour of alcohol can possibly escape. The wick is cylindrical, and made of silk *i*, it is passed over a tube *h*, which has a small nut inside, and is pushed up and down by a screw *c*. A conical shield *e* is attached for protecting the eye of the observer, *f* is the gauze similar to that of the Davy lamp, but of unusual length, in order that the cap may develope itself more freely inside; the top of the lamp is supported in the usual manner by pillars *g*.

To illustrate Mr T. W. I

FIG. I.

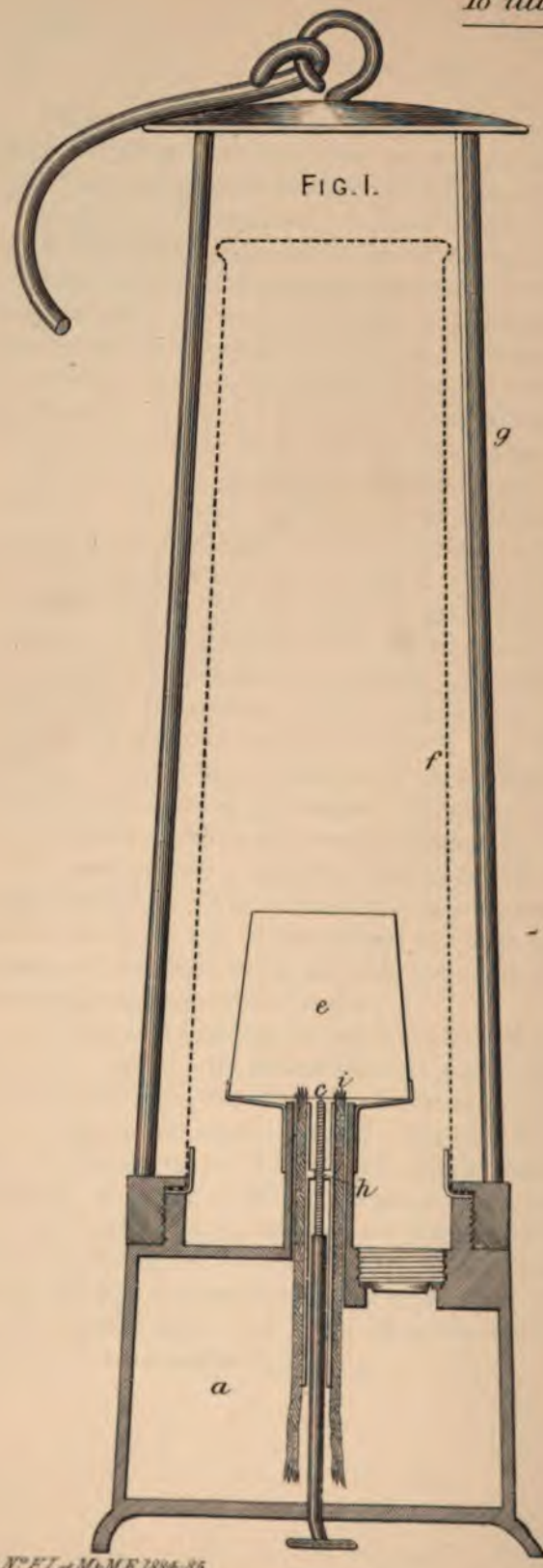


FIG. 2.

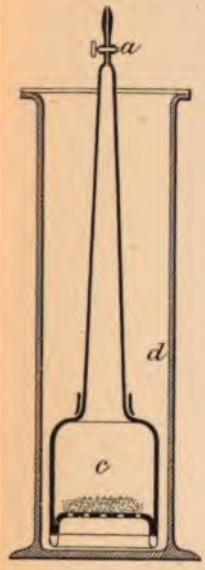


FIG. 4.

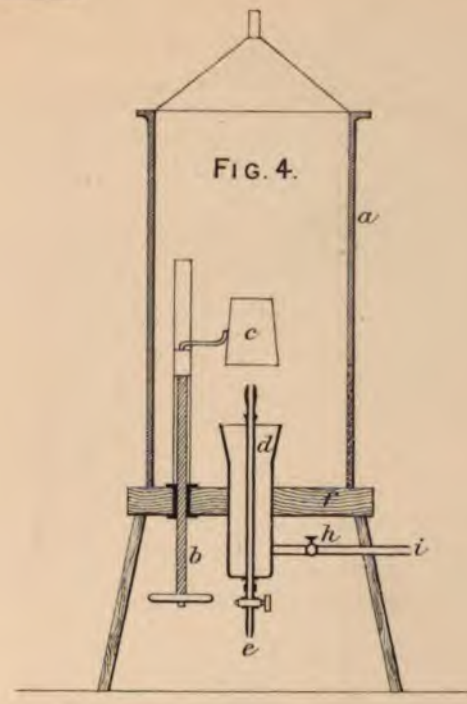


FIG. 3.

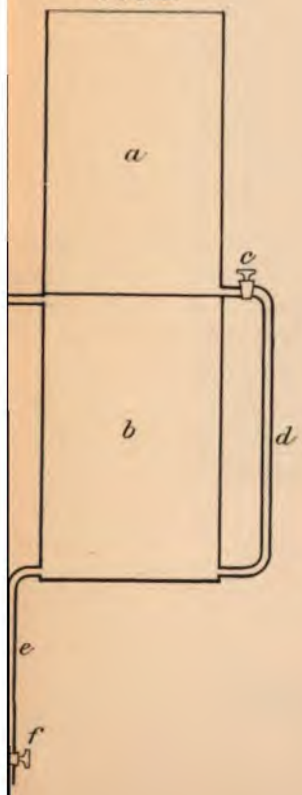
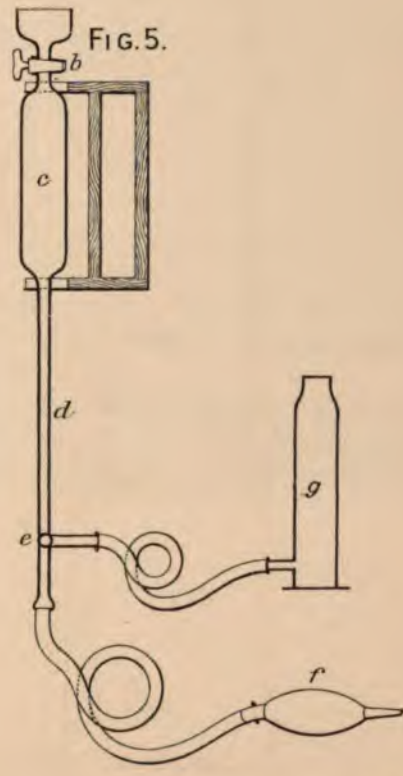
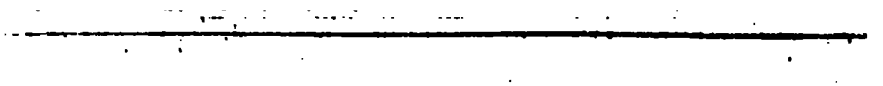


FIG. 5.





The receptacle of the spirit is made large so as to suffice for a prolonged journey through the workings.

According to the experiments made hitherto—

The cap with ¼ per cent. of fire-damp is of a bluish-grey colour, and but slightly luminous; it has a height of 1⅛ inches.

With ½ per cent. the cap reaches 2 inches, is more sharply defined at the bottom, but fades away above.

With ¾ per cent. the cap reaches 3 inches, the edges are sharper, and the colour more blue.

With 1 per cent. the cap reaches 3½ inches; edges more sharply defined, colour deeper blue.

With 1¼ per cent. the cap reaches 4 inches.

With 1½ per cent. the cap reaches 4¾ inches.

With 1¾ per cent. the cap reaches the top of the lamp, the luminosity is increased in proportion, and the colour of the cap is deep blue.

With 2 per cent. the cap widens out at the top, and with higher percentages it continues to expand, until the inner gauze is filled.

Fig. 5 shows the apparatus for ascertaining the amount of carbonic acid gas that may be in the atmosphere of a pit. It is composed of a burette *c*, with glass cock *b*, the long stem *d* of the burette being graduated to indicate definite proportions of the contents of *c*. *e* is a three-way cock, and *g* a receptacle for potass; *f* is an india-rubber pump which draws the air to be experimented on into the burette through the cock *b*. When that is full the cock *e* is closed, and the contents of *c* are in free communication with the potass in *g*. The contents of *g* and *c* are then shaken together, so as to mix them as much as possible, when, if there is any carbonic acid gas in the burette *c*, it will have been absorbed by the potass, and its place will be occupied by a portion of the fluid passing out of *g* into *d*, and when *g* is moved up or down so that the top of the fluid in *g* is on a level with that in *d*, so that no undue pressure may be exerted to raise the level in *d*, the gradations on the stem will indicate the percentage of the gas which previously existed in the mixture, and which has been absorbed by the potass.

The pamphlet in which Herr Pieler explains his lamp, contains a copy of one of the monthly calculations kept at the Gouley mine, and which, as it is exceedingly interesting, the translator has added to this notice.

RESULTS OF OBSERVATIONS ON THE VENTILATION

No.	Description of the Air Splits.	Workings.									Greatest Length of the Ventilating Current.
		Output in 24 hrs.	Employed in Workings.			In Constant Work.			Area of Seam exposed to the Ventilating Current.		
			Men	Horses.	Total.	Boards.	Pillars.	Other Workings.	In the Workings.	In the Old Workings.	
		Tons.							Sq. Feet.	Sq. Feet.	Yards.
I.	Ath. Gouley.										
	Split 1*a* ...	55	19	1	23	...	4	...	248,400	...	2,616
	„ 1*b* ...	113	62	1	66	9	8	1	1,134,000	10,800	5,232
	„ 1*c* ...	...	...	...	...	...	...	...	...	432,000	...
	„ 1*d* ...	84	47	1	51	4	7	...	453,600	270,000	4,251
	„ 1*e* ...	...	...	...	...	...	...	...	...	2,160,000	...
	„ 1*f* ...	18	12	...	12	4	...	...	43,200	...	2,943
	Total — Ath. Gouley ...	270	140	3	152	17	19	1	1,879,200	2,872,800	...
II.	Gemeins Shaft										
	Split II*a* ...	18	10	1	14	2	1	...	194,400	75,600	5,559
	„ II*b* ...	46	30	...	30	5	...	3	356,400	864,000	5,046
	„ II*c* ...	...	...	...	...	...	...	...	...	1,274,400	...
	„ II*d* ...	228	132	13	184	8	16	3	1,231,200	1,522,800	8,175
	Total— Gemeins Shaft	292	172	14	228	15	17	6	1,782,000	3,736,800	...
III.	Teut-Königs Pit										
	Split III*a* ...	100	44	4	60	2	5	1	226,800	113,400	3,488
	„ III*b* ...	120	70	...	70	10	4	...	788,400	...	5,777
	„ III*c* ...	30	24	1	28	...	1	3	237,600	10,800	4,687
	„ IV*d* ...	100	48	...	48	6	5	1	777,600	216,000	3,924
	Total—Teut-Königs Pit	350	186	5	206	18	15	5	2,030,400	340,200	...
	Grand Total	912	498	22	586	50	51	12	5,691,600	6,949,800	...

DURING THE MONTH OF NOVEMBER, 1882.

Cubic Feet of Air per Minute.					Gas Given Out—Cubic Feet in 24 Hours.				Carbonic Acid Gas given out in 24 Hours.	
Total.	Per 1000 Square Feet of Exposed Area of Seam.		Per Daily Ton of Output.	Per each Man in the Workings.	Total.	Per 1000 Square Feet of Exposed Area of Seam.		Per Ton of Output.	Per Cent. of Air admitted.	Total Quantity in Cubic Feet in 24 Hours.
	In the Workings.	In the Old Workings.				In the Workings.	In the Old Workings.			
2,894	11·65	...	52·6	126·0	...	...	...	...		
2,682	2·34		23·7	40·6	17,720	15·48		139		
211	...	0·49	...	...	37,135	...	85·9	...		
10,872	15·02		129·4	213·1	39,112	54·5		465		
1,482	...	0·68	...	...	37,135	...	17·2	...		
2,365	54·74	...	131·4	197·0	17,049	396·4	...	947		
20,506	4·31		75·9	134·9	148,151	31·2		548	·7	207,422
741	2·74		41·1	52·9	2,753	10·2		153		
4,800	3·93		104·3	160·0	5,118	4·2		111		
229	...	0·18	...	...	33,040	...	25·9	...		
13,414	4·87		58·8	72·9	28,240	10·2		124		
19,184	3·47		65·7	84·1	69,151	12·5		236	·2	52,985
4,341	12·76		43·4	72·3	15,637	45·9		156		
7,907	10·03	...	65·9	112·9	28,487	36·1	...	237		
6,389	25·72		212·9	228·1	23,050	92·8		768		
3,071	3·09		30·7	64·0	...	...	...	...		
21,708	9·15		62·0	105·3	67,174	28·3		192	·2	60,010
61,398	4·85		67·3	104·8	284,476	22·5		312	...	...

THE WOLF SAFETY-LAMP.

By T. W. BUNNING.

This safety-lamp is made to burn benzine ($C_7 H_{16}$), and is the subject of an exhaustive report made by the Mines Inspectors, G. Kreischer and Dr. Cl. Winkler, the latter Professor of Chemistry to the Royal College of Mining at Freiburg, to the Saxon Royal Commission to inquire into and revise the police regulations for securing the safety of mines.

This report treats of the subject in a great measure from a chemical point of view, and Dr. Bedson has kindly promised to make such an abstract of it as will bring its leading conclusions fairly before the members, so that the writer has now simply to confine himself to the description of the mechanical arrangements of the lamp, which are illustrated in Plate XLI.

The oil vessel *a*, Fig. 1, which, as usual, forms the bottom portion of the lamp, is divided by a diaphragm into two cavities; one, *b*, filled with cotton waste for holding the benzine, and the other, *c*, very much smaller, for holding the apparatus which is used to re-light the lamp without unscrewing it, should it at any time go out. The benzine is introduced through the hole *d*, closed by means of a screw. The wick is circular and about $\frac{1}{4}$ of an inch in diameter, and is brought up through a small tube *e*; a small conical regulating cap *f*, moved up and down by a screw *g*, regulates the height of the flame, which, as this screw traverses a small tube in the oil vessel *a*, can be raised at pleasure.

Figs. 5 and 6 show the mode by which the lamp is unlocked. *a* is a magnet, and *b* is a small plate which can rotate round its centre; by placing the lamp in the position indicated in the figure, so that the name-plate is between the legs of the magnet, Fig. 5, the spring *c* is withdrawn, and the bottom can be unscrewed. It will be seen by the shape of the spring and notches that the magnet is not necessary to enable the bottom to be screwed on.

The relighting apparatus, Figs. 3 and 4, consists of a brass sheet frame *h*, with an oval projection *i* round it about two-thirds from the bottom, with a hammer *j* so fastened on to the frame at *b* that it forms a spring; *k* is a strip of paper with fulminating spots; *ll* are two slots in the frame *h*, which serve as guides to the sliding piece *m*, with its rod *m'* running down one side of the frame and guided in the tube *n*; *qq* are two holes in the hammer *j*, in which works a trigger *x* attached to *m* by a pin, this

trigger is kept in its place by the spring *p*. When *m* is drawn down in the position shown in the figure, the trigger enters into the lower hole *q* of the hammer *j*, and when *m* is forced up the toe gives way and forces the spring *p* against the fulminating paper *k*; when the spring *p* can yield no further, the toe forces out the hammer *j*, and when, ultimately, the trigger is released, the paper has been forced up, the hammer has exploded one of the fulminating projections *k'*, and the trigger has entered the upper hole of the hammer *j*; the rod *m* is then drawn down the trigger, allowing it to descend, and all is ready for another blow; the whole is kept in the place in the base of the lamp by the ring *i* and the screw *i'*, Fig. 1.

The oil receptacle *a* has a screwed projection *a'* in which are cut a number of notches *r*, Fig. 6, to receive the bottom ring *s*, Fig. 2, of the connecting framework of the lamp; this ring is furnished with a pawl *s'*, Fig. 6, which is kept projecting by a spring and withdrawn by means of a magnet, to be hereafter described. From this project five upright pillars carrying the centre ring, which is made of iron and pierced with holes to allow air to enter between the shield *t*, Fig. 2, and the gauze *u*, Fig. 1; from this ring four pillars carry the top *v*, Fig. 2, to which is appended the hook for carrying the lamp and securing it.

Inside the projection *a'* of the oil receiver *a* is a brass ring *w*, Fig. 1, perforated with holes, which allow the air coming through the holes *a''* to pass through a wire gauze and feed the flame of the lamp; a washer *w'* then comes on the top of this ring and carries the glass *x* and the double gauze *u* and *u'*; a shield *t* is lastly secured round the upper part of the lamp between the centre ring and the top.

Fig. 2, Plate XLII., shows the construction of an apparatus used for filling the lamps: *a* is a can capable of holding about 50 lbs. of the benzine; it has a very small hole in the top *a'*, closed by a light brass spring which allows air to enter when the benzine is withdrawn, but which prevents any escape of gas; *b* is a glass measure containing the exact quantity necessary for charging one lamp. This is filled by lifting up the handle of the three-way cock *c*, when the benzine flows in from the bottom, the air in the top of the glass measure passing through and escaping by the pipe *e*. When the measure *b* is full, the lamp is put under the spout *c* and the handle is turned down, when the benzine flows through *f* into the lamp, air passing on to the top of the benzine through pipe *e*; should the absorbing matter in the lamp already contain some benzine and not require the full contents of the measure *b* to fill it, that which remains over will rise in the well of the lamp, close the end of the pipe *e*, and be drawn up it by the air rushing in till it is

at the same level as the benzine in the measure, when it will stop, and as no more air can enter above the benzine no oil can pass out of the cock. This simple automatic contrivance prevents all waste of the oil.

Fig. 1 is an apparatus used for testing the lamp: *a* is a cylinder three parts full of water; *b* is another cylinder inserted in the former, this cylinder has a valve opening inwards at *c*; *d* is a pipe which reaches some distance above the water line *d'* and passes out through the bottom of the vessel to the cock *e*. By pressing open the valve *c* with the fingers, the cylinder *b* can be raised, and as it falls it closes the valve *c*, and forces air through the pipe *d* and cock *e* into the vessel *f*, which is filled with a number of sheet iron partitions, between which some absorbing material, such as cotton wool, is confined. Benzine is allowed to flow among this material from the vessel *g*, by means of the cock *h*; the air passing through this vessel gets absorbed with benzine vapour, and is poured into the circular can by means of the spiral pipe *k*, which is perforated with small holes; at the bottom of the can there are holes for the admission of air; these holes may be opened or closed to any extent by a ring applied to the inside, which can be moved by the knob *l*. The lamp to be tested is lighted and inserted within the coil, the cock *i* is opened and the benzine vapour allowed to reach the lamp. If the lamp is defective the vapour will be ignited; if not, the lamp will go out, or exhibit the same signs as are observed when it is surrounded by small quantities of fire-damp. Ordinary street gas can be substituted for the benzine vapour.

This lamp was tested by Mr. M. Walton Brown, at Pelaw Colliery, by the kind permission of Mr. William Armstrong, and the following is his report:—

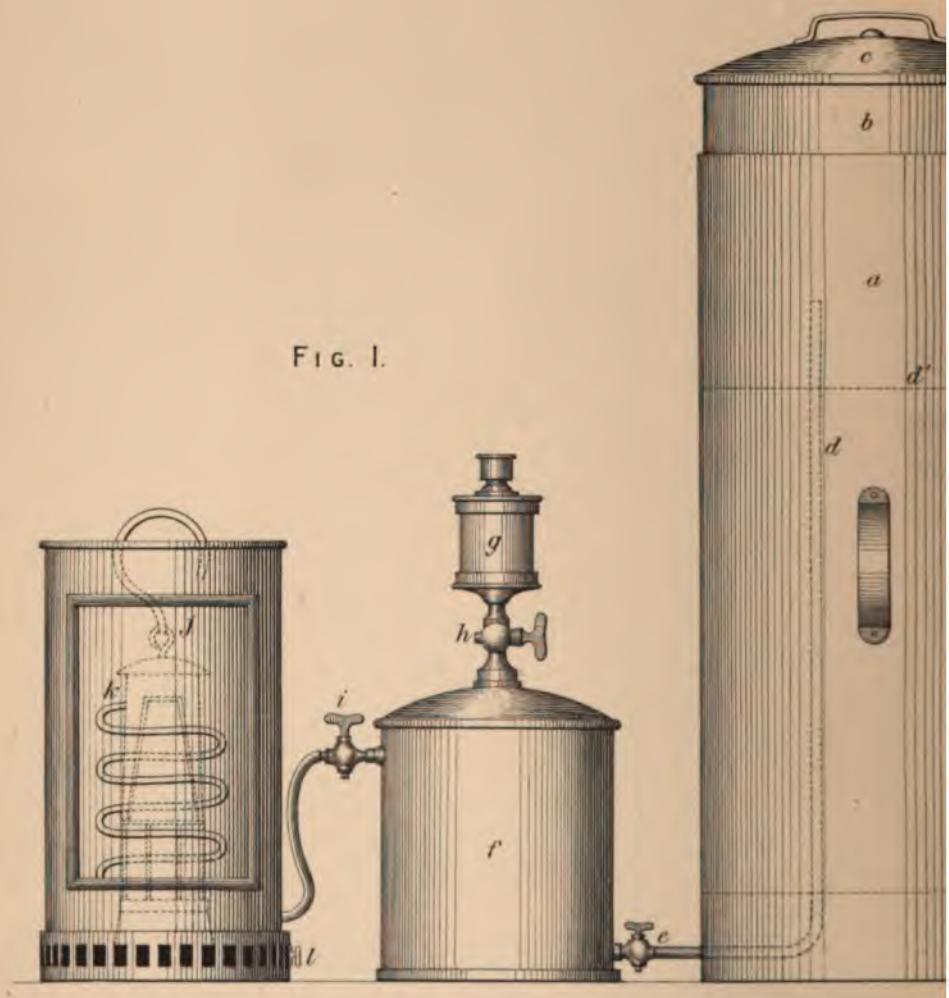
The lamp testing apparatus at Pelton Colliery consists of a rectangular box, with an internal section of 14 inches by 8 inches, and about 15 feet in length. A pipe for the introduction of gas is placed at one end, then a few inches off a gauze is placed, which prevents the flashing out of the flame when the explosive mixture is fired. There are two glass windows, 8 inches by 14 inches, for observations, and two flaps 14 inches long are placed immediately above them. These flaps relieve the pressure of an explosion, and give ready access to the box at the windows. Beyond the windows is a slide, which regulates the flow of the air through the pipe to the ventilating fan. The gas and air pass over a distance of about 10 feet before reaching the lamp, and this ensures a proper mixture. The explosiveness of the mixture was tested by placing an ordinary Davy Lamp in the current.

Experiments made July 27th, 1885:—

No.	Description of Lamp.	Remarks on the Lamp.	Velocity of explosive current in feet per second.	Remarks on Experiments.
1	Davy	... ...	7½	Flame extinguished, and gas burned inside gauze for 3 seconds, and then fired the gas outside.
2	Marsaut ..	With small conical shield	7½	Went out altogether in 3 seconds.
3	Wolf ... ... (With air-holes under the glass)	With removable shield	7½	Gas burned inside the inner gauze for 95 seconds, and then fired the gas outside. Flashes of vapour of oil.
4	Do.	Lamp as before ...	7½	Gas burned inside the inner gauze for 3 minutes. 40 flashes of vapour of oil. Experiment discontinued.
5	Do.	Lamp as before ...	9½	Gas burned inside the inner gauze for 3 minutes. 50 flashes of vapour of oil. Experiment discontinued.
6	Do.	Lamp as before ...	11½	Gas burned inside the inner gauze for 1½ minutes. 13 flashes of vapour of oil. Experiment discontinued.
	As the lamp had been in the apparatus and gas burning continuously within inner gauze for about 10 minutes, it was removed from the box.			
7	Do.	Without shield ...	11½	Showed gas, and all went out in 9 seconds.
	It was now found that the shield could be placed so as to give a small opening at either top or bottom.			
8	Do.	With shield down ...	9½	Gas burned in inner gauze for 40 seconds (the oil vapour exploding 4 times in first 25 seconds), when experiment was discontinued.
9	Davy	... ...	9½	Flame extinguished, and gas burned inside gauze for 4 seconds, and then fired the external gas.
10	Wolf	With shield down ...	9½	Gas burned inside of inner gauze for 2 minutes, with 30 explosions of vapour of oil, and the experiment was discontinued.
11	Do.	With shield up ...	9½	Gas burned inside of inner gauze for 2 minutes, with 15 explosions of vapour of oil, and experiment was discontinued.
12	Do.	With shield up ...	11½	Gas burned inside of inner gauze for 2 minutes, with 20 explosions of vapour of oil, and experiment was discontinued.
13	Do.	With shield up ...	15½	Gas burned inside of inner gauze for 2 minutes, with explosions of vapour of oil, and experiment was discontinued.
14	Do.	With shield up ...	Unknown, but lamp was blown over.	Gas burned inside of inner gauze for 3 minutes, with explosions of vapour of oil. Experiment was discontinued when lamp was blown over.
15	Davy	... ...	11½	Fired gas instantly, and all extinguished.
16	Marsaut ...	As before	11½	Flame extinguished and gas burned in the inner gauze for 3½ minutes, when the experiment was discontinued.

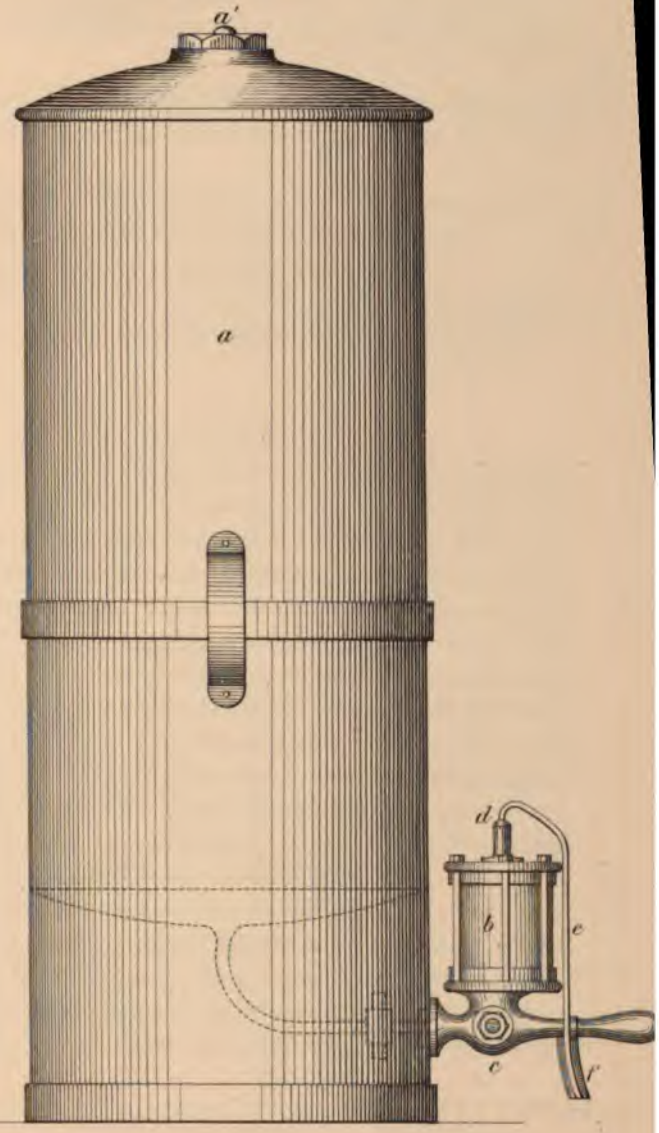
To illustrate Mr T W Burn

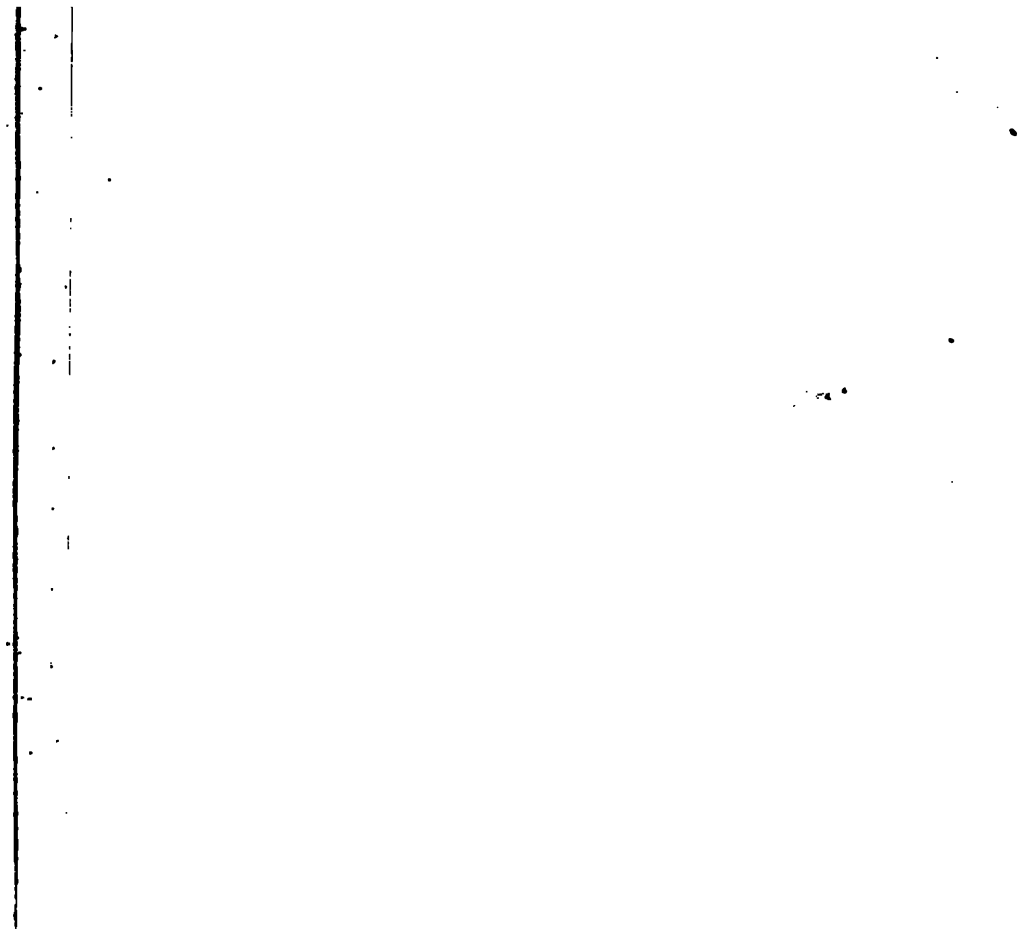
FIG. I.



aper "On the Wolf Lamp."

FIG. 2





Mr. OEXLE, the representative of the manufacturers, showed the working of the lamp.

The PRESIDENT said the members had had the opportunity of hearing the descriptions of these two lamps, both of which were of a novel, and apparently useful, character. They were much obliged to Mr. Bunning for bringing the lamps before their notice, and also to the manufacturers for sending a gentleman to explain the Wolf lamp.

Mr. G. B. FORSTER—Will the Wolf lamp burn with ordinary vegetable oil ?

The SECRETARY—The lighting apparatus will be perfectly useless with oil. There must be a spirit giving out gas to enable the striking apparatus to fire.

Mr. G. B. FORSTER—Then, according to the Belgian regulations for fiery mines, this lamp would not be admissible in that country.

Mr. OEXLE—They do use it in some places in Belgium.

Mr. G. B. FORSTER—Yes, in non-fiery mines ; but, according to the regulations in Belgium, only vegetable oil is to be used in fiery mines.

THE ROUTLEDGE LAMP.

Mr. WEEKS said, Mr. Ellis Lever had very properly called his attention to the report of his remarks on the discussion of the Routledge lamp, which took place on the 11th April last, and in which he (Mr. Weeks) was stated to have said that Mr. Ellis "had taken care to make the conditions under which the prize would be given such as were impossible for any person to comply with." While not calling in question the accuracy of the report, he wished to say that it was his intention merely to give an expression of his own individual opinion that the conditions were, in his judgment, incapable of performance. The words which he was reported to have used, however, had caused Mr. Lever to think that he was impugning his *bonâ fides*. He sincerely regretted that the words should have been such as could by any possibility bear that construction, as nothing was more remote from his mind than an intention to impute want of good faith to Mr. Lever or to the adjudicators (who, he had since learned from Mr. Burt, M.P., one of them, and whose letter was appended, settled the conditions), though he (Mr. Weeks) admitted that the words as reported reasonably bear that construction ; and he now begged to withdraw the expression which he unintentionally used, and which he was sorry should have caused Mr. Lever any pain.

(*Copy of Letter referred to.*)

"LONDON, June 25th, 1885.

"My attention has been called to some remarks made by you at a meeting of the North of England Institute of Mining Engineers (Transactions, page 189) relative to the prize of £500 offered some time ago by Mr. Ellis Lever. I have no wish to discuss the reasonableness or otherwise of the conditions; but, in justice to Mr. Lever, I beg to inform you that he offered the prize without any conditions whatever. The conditions were arranged by the Central Board of the Miners' National Union, after consultation with the adjudicators. The adjudicators were, Sir F. Abel, Professor Adams, and Professor Sylvester Thompson and myself, representing respectively the Society of Arts, the Royal Society, Mr. Lever, and the Miners' National Union. The Coal-Owners were asked, but declined to appoint a representative. In justice to Mr. Lever, who has for many years taken a keen and an unselfish interest in questions affecting the loss of life in mines, I hope you will think it right to take steps to correct the unfavourable impression likely to be made by the words to which I have called your attention."

The SECRETARY read the following translation of a paper on "Further Results of Experiments with Coal-Dust at Neunkirchen:"—

FURTHER RESULTS OF EXPERIMENTS WITH COAL-DUST AT NEUNKIRCHEN.

TRANSLATED BY T. W. BUNNING.

THE scientific and technical section of the Prussian Commission on Gas met on the 18th May, and received most interesting communications of the more recent experiments made in the gallery at the König mine, near Neunkirchen. It had been thought by several parties that shot-holes charged with dynamite would not inflame coal-dust. This supposition has been confirmed, at least in cases where there has been a total absence of gas, when it has never been found that dynamite would ignite the coal-dust, even when a shot was stemmed with dust of the most inflammable description, and when this dust was strewed all round about; and when a block of coal, after having been completely covered over with coal-dust, was blown to pieces by dynamite, no ignition of the dust took place. Neither was dust inflamed by a shot in a block of coal covered with dust and charged with ordinary powder, which blew it to pieces, but when powder was burned freely in the air the dust was ignited.

These experiments prove, then, the absence of danger when dynamite is employed, when there is no trace of gas.

Another set of experiments will take place to find out the influence of dynamite on dusts in the presence of certain quantities of gas. If, under these conditions, the dusts are not inflamed, a great step will have been taken in elucidating the question of shot-firing in coal-mines.

Nevertheless, the danger of setting fire by dynamite to large quantities of gas disengaged from the encasing strata will always exist; for it has been often observed that in working in the carboniferous sandstone, giving out a great quantity of gas, the front of the face was filled with flame after the explosion of each shot.

Other experiments have shown that an explosion can be transmitted to dust situated at a great distance from where the explosion first took place.

The length of the experimental gallery at Neunkirchen is, as is known, 164 feet; at a distance of 93·5 feet from the front of the shot holes, a lateral

gallery, 38 feet long, was placed. The mouths of these two galleries were closed during the experiment in question; the principal gallery with a door of wood strengthened with iron, and the other with sailcloth. In the main gallery a partition of sailcloth was made, 40 feet from the front of the shots, and containing 882 cubic feet. This was filled with 7 per cent. of gas. The bottom of the side gallery was strewed throughout its entire length with very inflammable dust without the least trace of gas. There was, therefore, a space of 55·76 feet between the chamber which contained the gas, and the dust in the side gallery, altogether free from either gas or coal-dust. The gas was fired by a shot stemmed with dust; at first a deep toned detonation was heard, followed immediately afterwards by a formidable explosion. The side gallery was filled throughout its whole length with flames in violent oscillation, which leaped many feet outside the gallery, followed by a thick black after-damp.

In the principal gallery the flame had a length of upwards of 144·32 feet. The wooden door at the entrance was completely destroyed, and the remains, shattered in little pieces, were thrown a long distance. The iron frame of the door was bent and broken in several pieces; the gallery was damaged in many places, and the fittings of the windows destroyed. The first window in the side gallery from the end nearest the opening was clean blown away as if cut out by a saw. The bottom of the principal gallery was covered for a short distance from the end, and that of the side gallery through its entire length, with dirt from the ground close by, brought in by the return current. The part of the principal gallery, between the face of the shot and the branch gallery, remained intact. The explosion was the most violent in the side gallery, that is, where the dust was placed.

It has been proved by the experiments that a simple explosion of dust, which had been spread over 65·60 feet from the front of the shots, that is, spread to within 26·24 feet from the side gallery, was transmitted to the dust contained in the side gallery.

The experiments tried with wet dust were also very interesting. It was found that a small quantity of water was not of any use. Dust, to be rendered inoffensive, must be mixed with at least two-thirds of its weight of water.* In this state, when a quantity is taken up by the hand and formed into a ball, water is squeezed out. It is sufficient to damp the dust to the length of the flame caused by the shot; but as this distance, with inflammable dust and a very small quantity of gas, might reach 55·76 feet and more, it will be difficult, in practice generally, to apply water.

* The Secretary has since heard that these experiments have been incorrectly reported.

Blown-out shots, charged with 8½ ounces of powder, and stemmed with the dusts of dry coal, as those from Kohlscheid and Kœnigin Louise, have given, without dust being sprinkled and without gas, a length of flame of 31·16 feet, and these were augmented to 36·08 feet with 3 per cent. of gas.

Shots stemmed with rock dust produce but small lengths of flame, which, in the presence of small quantities of gas, are still shorter than the flame made by shots with clay stemming; and the addition of 50 per cent. of coal-dust to the rock dust does not sensibly increase the length of the flame.

In no case has it been possible to fire dust held in suspension in the gallery by means of a lamp or with a strong flame of gas; the dust only burned in the flame, with a low crackling noise, without exploding.

Experiments have also been made with dust of more or less fineness. The details of these experiments will soon be published.

It is much to the credit of Mr. Inspector Margraf that these latter important experiments have been completed in such a short time.

The PRESIDENT said, the discussion would now be taken upon the paper which Mr. Bunning had read upon this subject. He was glad to see that they had present among them again Mr. Galloway, who had taken such great interest in this subject, and who was the first to bring it before the mining world. Any gentleman who had any remarks to make or questions to ask would perhaps do so now, and Mr. Galloway would answer them. He (the President) wished to make a few remarks upon what appeared to be some very important points respecting the results of the experiments; and he would make his remarks now, before Mr. Galloway spoke, so that that gentleman might corroborate or contradict him. It seemed, first of all, that shots, in order to fire coal-dust, must be upon the floor, that a roof shot would not fire coal-dust that was on the floor in a mine; second, that the dust must be very thick, from 1 to 2 inches at least; third, that it must be a blown-out shot; and fourth, that the shot must be in the direction of the gallery. He almost ventured to think these were four conditions that rarely, if ever, occurred all together in coal mines. They had in the paper information that dynamite would not ignite the dust at all.

Mr. T. W. CRAWFORD asked Mr. Galloway if he had tried cartridges composed of any other material for stemming, one, for instance, composed of an india-rubber tube filled with water?

Mr. GALLOWAY said, he intended to say something to-day about trying dynamite water-cartridges.

Mr. GREENWELL said, it appeared to him, from what Mr. Bunning had read, that they were led to infer that the dust in a side gallery could be ignited. One condition, which ought to be borne in mind, had not been stated. He once made an experiment with a box, which had a side gallery to it, and there was a balance valve on the top of the box in the side gallery. On firing the shot at the fast end of the main gallery, the valve at the top of the side gallery was pressed inward by the draught, showing an exhaust from the side into the main gallery. In considering the point raised by Mr. Bunning, he thought they ought to take this condition of things into account, that, although the dust in the side gallery might be fired, it would not be quiescent dust, but dust that was raised in it by the action of the draught along the main gallery into which it was drawn.

The SECRETARY said, the paper stated that they could not get an explosion from one quantity of gas to another in the main gallery, simply because the first explosion drove the second portion of gas out of the tunnel before the flame could get to it; but when gas was put into the side, and the outer end was closed so that there could be no current coming inward towards the main gallery, then they could fire the gas and fire the coal-dust without the gas.

Mr. SYDNEY F. WALKER asked whether experiments had ever been made to neutralise gases in the places where they were formed? If he understood the matter aright, the deadly character of explosive gases in mine, arose from the fact that they had such a strong affinity to the oxygen in the atmosphere, that, in the presence of sufficient heat or flame, they practically absorbed it all by chemical combination, leaving the atmosphere unable to support human life. It occurred to him to ask whether any experiment had ever been tried to supply oxygen in mines to neutralize the gases, so that the atmosphere might not be left in a deadly state. On reading the accounts of some explosions which had occurred, he had noticed that parts of mines had been cut off through the mechanical effects of the explosions—bratticing torn away, doors blown down, and the air current going in another direction and cutting off a certain part of the mine where perhaps some men had been at work. It appeared to him that if supplies of compressed air

could have been placed there to be used in cases of necessity, for a certain time at any rate, it would enable the explorers to get to the men.

PROFESSOR HERSCHEL said, that at the last meeting Mr. Galloway remarked that a certain density of gas and coal-dust was necessary for communicating or making an explosion, and that that density was one which they could scarcely expect or think probable to exist. It appeared to him (Professor Herschel) that perhaps the shock of the explosion was able to stir the dust in the way that had been described, by a kind of draught on the surface, or vibration of the surface. The shock might make the dust rise in clouds, and form a sort of lining or coating in a very dense coally atmosphere, and along this coally atmosphere the explosion might probably be projected. He would like to ask Mr. Galloway if he had any such idea of the way coal-dust moved along the gallery?

PROFESSOR MERIVALE said, he thought that in Germany all the shots had been fired at the face of the drift, that was at the closed end. He asked whether any shots had been fired at the open end, and in the sides; and if so, had they succeeded in producing an explosion? One would be inclined to think they would not.

MR. GALLOWAY said, that in regard to the questions asked by the President, he would say that the shots near the floor appeared to give the best results, but the shots higher up sometimes ignited the coal-dust. Some of the experiments at Neunkirchen showed this; when they placed dust on shelves to represent the timbers in mines, the shots produced the same result as shots in the bottom. He might refer to the case of the last explosion at Risca. He happened to be at that colliery about a fortnight ago, and saw the position of two shots that were fired at the time the explosion took place. Four men had gone in to light the shots on the Sunday. They had lighted four shots in the intake air-way, and, being there when the explosion took place, they were killed. The explosion went through the whole length and breadth of the mine, and damaged the workings as much as any previous explosion had done; but as only four men were killed very little was said about it in the newspapers or elsewhere. One of the shots was in the roof, about 5 feet above the floor; another, for the purpose of heightening a manhole, was also about the same height above the floor. The one in the roof was directed length-ways along the gallery, and the one for the manhole was across it. It was supposed that the two shots had gone off within a very short time of each other; that the one length-ways in the gallery, fired and raised a cloud of dust, and that the other completed the disturbance to such an extent as to enable the explosion to commence. After the

explosion had once commenced, it proceeded through the mine in the way Professor Herschel had imagined; the disturbance raised the dust from the floor and from all surfaces on which it was lying, and created an atmosphere containing coal-dust mixed with air. The second point raised by the President was, as to the dust lying very thick—2 inches thick; he presumed the President meant dust lying upon the floor of the gallery.

The PRESIDENT—Yes.

Mr. GALLOWAY said, that according to his experience it is not necessary for the dust to be so thick. In his experiments he put the dust usually only about a quarter of an inch thick.

The PRESIDENT—But the area of the box would be very small.

Mr. GALLOWAY—Four square feet.

The PRESIDENT—In a mine there would be a larger area through which to form the dust cloud.

Mr. GALLOWAY said, in his experiments only a slight film was swept off the surface, and the rest of the dust was left untouched. The explosion did not raise the whole of the dust from the floor, but only a film. When he had his box swept out as completely as possible, and made as free from dust as it could be, the remaining dust still produced an explosion. The dust was swept out by means of a brush, and still the flame passed along some distance over the remaining slight dust in the box.

Sir LOWTHIAN BELL—Gas being present?

Mr. GALLOWAY—No, no gas. As regarded the use of dynamite for avoiding explosions of dust, the descriptions of the German experiments were not clear. They only stated the fact that dynamite did not create an explosion. Before pronouncing an opinion upon this point, he would like to know how the experiments were made; his own experience being that in firing shots with dynamite in any kind of cannon, like those used by the Germans for their gunpowder shots, the cannon had usually burst. He had made a large number of dynamite experiments of one kind and another for the Commissioners on Accidents in Mines, and he had been obliged to have resort to other means to make blown-out shots. It was only a blown-out shot that would have the effect. He thought the Chesterfield Institute had tried some experiments with small quantities of explosive substances surrounded with dry coal-dust. They put small quantities of dynamite or gunpowder into a box in which there was coal-dust, and exploded them; but he did not think the results were very conclusive. Similarly, he should not think any results of these experiments by the German Commission, with dynamite or powder exploded

in a lump of coal, were of any particular value. He would like to know how they arrived at the conclusion they had formed that blown-out shots, charged with dynamite, would not create an explosion of dust. He had made a large number of experiments with dynamite water-cartridges, invented by Sir Frederic Abel, which were placed in the hole and fired by electricity. The result was that a few sparks were seen to come out of the hole, even through 4 feet of water. He did not think he could at present go further into the matter, because the results of the experiments had not been published, and he would leave it to the Commissioners to give them more definitely. After making these experiments he pronounced the decided opinion to the Commissioners that shots of this kind, fired in a coal-dusty mine, would not produce an explosion; that they would be quite innoxious in the presence of dry coal-dust. In the additional paper which Mr. Bunning had read, the German Commissioners stated that the dust required two-thirds of its weight of water to prevent it from igniting. His own experience was that very little dampness was sufficient to prevent dust from igniting. He made experiments in a gallery 2 feet square by 120 feet long. On a fine warm day he was able to get a flame varying from 100 to 147 feet in length by the explosion of a mixture of 1½ cubic feet of gas and air at one end; but on the following day, when there was a little dampness in the air, without watering the dust at all, the flame did not extend more than 20 or 30 feet. When he was in Germany, Herr Margraf, who made the experiments, told him that his experience was exactly the same. On damp days, and even when using perfectly dry dust, they would not get the flame to extend as on dry days, and this did not look as if the dust required two-thirds of its weight of water to prevent its inflaming. He had noticed in dusty collieries where small local explosions had been caused by shots, that the flame invariably stopped when it came to a part of the colliery where the dust was only damp, and not wet as they seemed to say it should be. At Abercarne explosion, which happened about 1878, when a large number of men were killed, there was one little district separated from the others by a damp road, 200 yards long, from which 70 men escaped alive. He had lately seen that place, and he was satisfied that the 200 yards of damp road had saved the lives of those men. He noticed in the accounts of the Clifton Hall Colliery explosion, that one of the witnesses stated that they were in the habit of watering the roads. But the first accounts of the explosion stated that a great balloon-shaped cloud of dust and smoke had been ejected from one of the shafts. That of itself, was, to his mind, proof that either the watering

was entirely neglected, or that it was very imperfectly done. He could come to no other conclusion. The last German paper read by Mr. Bunning stated that it would not be a very practical thing to water the dust, because the flame of a shot in which dry coal-dust was used as stemming, extended to a distance of 55·76 feet, in the presence of gas. Now the first question that occurred to himself was this, why put in dry coal-dust stemming at all? Why not use stemming of the ordinary description, such as was employed when they did not want to create a long flame? If they did not put in the coal-dust the flame was only 13 feet long, and consequently watering could easily be carried out. With 6 per cent. of gas in the air, the flame was lengthened out to 45 feet, so that if they fired shots, even in that dangerous condition of the air, it was only necessary to water 45 to 50 feet from the hole. But no one would think of firing shots where any gas could be detected at all; consequently he did not look upon this expression of opinion of the impracticability of watering in front of the place where the shot was to be fired as being very important. He was curious to see the details of the experiments. There was only one more question, and that was as to the firing of shots at the closed end of the gallery. None of the shots were fired in any other position except at the closed end in the German experiments. He did not know of any experiments in which shots were fired elsewhere except those of the late Professor Freire-Marreco, who, he thought, fired shots across his experimental gallery; and there were also the shots fired in Risca Colliery, to which he had referred. As a rule, he thought the dangerous shots were those fired at the closed end.

Mr. Matthew Heckels remarked, that seeing how important it was to prevent blown-out shots, he thought it would be useful to have a special rule in every colliery that no man should charge his shot until the hole had been properly examined by the deputy, who should then see that the charge was properly inserted and the stemming duly made with clay or some other authorised material; for instance, shots were very much more liable to be fast or blown-out when the hole was drilled 4 or 5 inches deeper than the nicking, and he thought that it would very much lessen the danger of blown-out shots if the holes were properly examined.

Mr. T. W. Crawford explained the system of blasting with water stemming, with powder or dynamite for an explosive charge. He had used about 18 inches or 2 feet of water stemming on one occasion with a blown-out shot, and the only approach to flame that was seen was the fuse by which the shot was fired being blown violently forward to where he and others were sitting.

Mr. GALLOWAY—Was it with dynamite or gunpowder?

Mr. T. W. CRAWFORD—With gunpowder, ordinary blasting powder.

Mr. GALLOWAY said, he had made experiments with these water-cartridges, with gunpowder, and had found that the gas was invariably fired, the shots being fired directly into explosive gas.

Mr. T. W. CRAWFORD said, of course his experiments were not made where gas was, but in a mine in an ordinary working condition.

Mr. GALLOWAY said, that was not the case with his, gas having been always present.

Mr. T. W. CRAWFORD asked if Mr. Galloway tried liquid carbonic acid?

Mr. GALLOWAY said he had, but he thought he would not be justified in speaking of this yet, because the accounts had just been sent to the Commissioners, who would probably publish their report very soon.

The PRESIDENT said, they had had a very interesting discussion upon a most important subject. The German experiments might not have succeeded in exploding coal-dust by dynamite, because it was not probable they got a blown-out shot by dynamite. It was more than probable that the dynamite, the action of which was so rapid, would develop its force inside the hole, rather than by blowing out the stemming. Water stemming had been frequently tried. He had made a number of experiments himself, and he thought he could always see flame after using water stemming. Still, other gentlemen might have succeeded in so arranging the shot-holes that the flame might not appear. He thought Mr. Galloway said he had succeeded in keeping the shot without flame.

Mr. GALLOWAY—Yes, but not in stopping sparks. Sparks have always come out.

The PRESIDENT asked Mr. Galloway if he thought the sparks such as would have ignited gas?

Mr. GALLOWAY—Yes.

The PRESIDENT said, Mr. Galloway had also mentioned the question of not using coal-dust for stemming. It certainly seemed a very easy way of preventing the passage of a long flame by using stone-dust instead of coal-dust; but until this fact was known, not only to themselves, but generally to the workmen, they (the workmen) did not see the necessity of not using coal-dust. He had no doubt after this that great care would be taken not to use coal-dust in stemming. Mr. Galloway also mentioned that in some of his experiments only a portion of the dust, with a blown-out shot, was ignited. Supposing this to be so, naturally a very small amount of water would have prevented it. If it was only a film that was

taken off the dry dust, then, if that film had been damped, the dust would not have risen at all.

Mr. GALLOWAY said, he had no doubt if he simply allowed a little jet of steam to go along the apparatus for one minute before the experiment it would have damped the dust sufficiently to have prevented an explosion.

Mr. GREENWELL said, that as to the question of broken stone for stemming, if they were firing shots in stone drifts, and if the hole was driven in the post or rock, and they stemmed with rock-dust (usually loose powder was used in firing the shot), and if the stemming was in rock, they would run the great chance of sparks from that igniting the powder and injuring the person stemming the hole. He did not think stemming next to the powder with anything of a softer character would do away with the danger, because traces of the powder would be on the sides of the hole, which might communicate a spark to the powder. It would be dangerous to let it go abroad that stone or rock stemming would be best.

Mr. G. B. FORSTER—What they really used in the experiments was clay, and not stone stemming?

Mr. GALLOWAY—Yes, soft wet clay. He thought Mr. Greenwell had not quite seen the point he (Mr. Galloway) wished to illustrate. He did not mean to say that using stone stemming would do away with the danger, but simply that it would make a shorter length of flame, supposing the shot were blown out.

Mr. GREENWELL said, he wanted to do away with any impression going forth that it was safer to use stone stemming than coal-dust stemming.

Mr. GALLOWAY—It would always be safer to use stone stemming than coal-dust.

Mr. LINDSAY WOOD said, that if they used coal stemming and got a flame thirteen or fourteen feet long, probably by using other stemming they would get a five-feet flame. He imagined that a five-feet flame would be equally as dangerous in gas as a thirteen or fifteen-feet flame would be in setting fire to coal-dust without gas. He asked Mr. Galloway if he had tried any experiment with stemming of different natures? There was no doubt that water did, to a considerable extent, allay the flame; there was a very much less flame with water. He asked whether the effect of the blown-out dust, irrespective of the stemming, caused the danger? It would be very dangerous if the idea got abroad that the stemming was the only thing to do with the matter. His impression was that stemming had very little to do with it; but he was speaking subject to correction.

Mr. GALLOWAY said, that stemming with coal-dust gave flames of thirty feet, and up to fifty or sixty feet; but with clay the flame was only

thirteen feet long. There was a great difference between thirteen feet and from forty to sixty feet. There was a greater element of safety with the shorter flame.

Mr. LINDSAY WOOD—Not with gas.

Mr. GALLOWAY—With coal-dust.

Mr. LINDSAY WOOD—Is there not great danger from the short flame?

Mr. GALLOWAY—It would be more easily provided against by watering when there is a short flame.

The PRESIDENT said, he thought the argument was this: that if the flame of a blown-out shot, stemmed with stone-dust, did not exceed ten feet, if the dust was removed for fifteen feet there could not be an explosion; but if they stemmed with coal-dust and had a flame of fifty feet, then they must remove the dust for that distance if they wanted to avoid an explosion. It was a question of removing the dust for fifteen feet or sixty feet from the shot-hole. That was the only question.

Mr. GALLOWAY—That is all.

The PRESIDENT—As to stemming, it is usual to damp the stemming put into shot-holes, and if that were done the danger of sparks would be, to a great extent, avoided.

Mr. HECKELS asked if it would not be possible, seeing that dust, when damped, did not explode, to add water to the air as it entered the pit, and so make the ventilation damp and prevent the dust becoming dry? He had seen shots light up in damp places, but only come back a few yards, and do no damage; and he had also seen them light up a dry place and come right out.

Mr. G. B. FORSTER proposed a vote of thanks to Mr. Galloway for his kindness in attending the meeting and stating the results of his experiments. He thought they were all very much indebted to Mr. Galloway for the great interest he had taken in the subject, and for the elaborate and careful experiments he had made. Though, perhaps, the subject might not yet have been fully thrashed out or determined, yet there was no doubt that their knowledge of coal-dust had been very greatly added to since Mr. Galloway commenced his experiments upon it. This coal-dust only added to the unknown dangers which threatened them underground. The only consolation was that people with wet pits, who grumbled so much about the water, would find themselves safer than their neighbours with dry pits.

Mr. E. F. BOYD said, he had very great pleasure in seconding the vote of thanks to Mr. Galloway. The subject which had been discussed was of very great importance to this country, and particularly to the eastern

part of their district, where there was so little water. The collieries at Hetton, East Hetton, and Seaham were particularly liable to this difficulty. Mr. Galloway's experiments would add materially to their information.

The motion was agreed to.

Mr. GALLOWAY returned thanks for the vote, and said he took great interest in this question, and he would always be glad to come this or any similar distance to discuss it with those who were so much interested in the subject.

BAROMETER AND THERMOMETER READINGS FOR 1885.

By the SECRETARY.

These readings have been obtained from the observations of Kew and Glasgow, and will give a very fair idea of the variations of temperature and atmospheric pressure in the intervening country, in which most of the mining operations in this country are carried on.

The Kew barometer is 34 feet, and the Glasgow barometer 180 feet above the sea level. The latter readings have been reduced to 32 feet above the sea level, by the addition of ·150 of an inch to each reading, and both readings are reduced to 32 degrees Fahrenheit.

The fatal accidents have been obtained from the Inspectors' reports, and are printed across the lines, showing the various readings. The name of the colliery at which the explosion took place is given first, then the number of deaths, followed by the district in which it happened.

At the request of the Council the exact readings at both Kew and Glasgow have been published in figures.

BAROMETER READINGS, &c.

JANUARY, 1884.

	KEW.						GLASGOW.					
	Barometer.				Temperature.		Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·341	30·305	30·229	30·180	36·5	32·1	1	30·405	30·369	30·272	30·193	39·9	37·0
2	30·132	30·101	30·029	29·981	43·2	36·6	2	30·094	30·049	29·996	29·956	38·7	30·3
3	29·908	29·914	29·948	30·016	49·8	42·3	3	29·884	29·875	29·887	29·955	36·9	27·1
4	30·067	30·135	30·161	30·168	49·2	44·8	4	29·974	29·995	29·989	29·963	41·2	36·8
5	30·128	30·018	29·841	29·822	49·4	44·2	5	29·806	29·594	29·414	29·353	51·0	41·1
6	29·811	29·802	29·787	29·855	51·3	44·0	6	29·339	29·357	29·429	29·584	47·9	43·9
7	29·897	29·959	29·878	30·009	46·7	40·6	7	29·677	29·680	29·763	29·927	44·5	38·0
8	30·126	30·170	30·088	30·184	46·9	37·2	8	29·868	29·739	29·836	29·801	49·3	38·8
9	30·220	30·271	30·294	30·371	51·2	42·6	9	29·765	29·797	29·890	29·988	50·2	46·0
10	30·367	30·390	30·335	30·271	51·0	42·4	10	29·944	29·923	29·887	29·798	46·9	43·0
11	30·088	30·018	30·060	30·212	47·0	38·2	11	29·640	29·677	29·835	30·101	43·2	34·7
12	30·316	30·388	30·395	30·440	43·1	34·9	12	30·226	30·287	30·266	30·285	45·1	36·2
13	30·443	30·466	30·429	30·441	45·1	35·5	13	30·273	30·272	30·231	30·227	46·4	42·9
14	30·413	30·423	30·371	30·423	49·1	40·0	14	30·129	30·143	30·243	30·342	49·1	45·4
15	30·483	30·542	30·552	30·587	50·1	40·6	15	30·405	30·463	30·487	30·503	48·9	45·8
16	30·594	30·627	30·613	30·624	43·9	38·1	16	30·495	30·509	30·494	30·482	47·0	42·0
17	30·591	30·590	30·569	30·570	42·8	39·8	17	30·438	30·407	30·376	30·389	46·1	41·5
18	30·558	30·570	30·527	30·537	46·0	40·2	18	30·373	30·369	30·318	30·276	48·0	44·3
19	30·546	30·604	30·597	30·560	46·1	38·2	19	30·212	30·295	30·288	30·159	48·2	45·7
20	30·472	30·476	30·427	30·383	50·2	40·1	20	29·887	30·081	30·053	29·823	48·8	41·5
21	30·380	30·490	30·491	30·469	50·4	42·2	21	29·941	30·177	30·078	29·823	49·8	41·0
22	30·319	30·224	30·048	29·871	51·9	46·1	22	29·699	29·675	29·527	29·580	46·9	38·9
23	29·875	29·675	29·280	29·404	54·2	43·1	23	29·605	29·086	28·439	29·055	45·3	37·5
24	29·603	29·856	29·904	29·918	43·4	37·1	24	29·391	29·521	29·525	29·329	40·1	31·0
25	29·785	29·656	29·493	29·433	46·8	38·0	25	29·135	29·087	29·011	29·065	40·7	30·3
26	29·086	29·262	28·820	28·601	49·4	38·5	26	28·963	28·773	27·931	27·457	42·2	30·0
27	28·835	29·116	29·158	29·165	40·0	33·7	27	28·050	28·437	28·564	28·683	37·8	30·1
28	29·296	29·586	29·785	29·871	43·9	35·0	28	28·919	29·226	29·460	29·553	39·1	33·4
29	29·776	29·766	29·757	29·829	53·8	38·1	29	29·539	29·367	29·175	29·410	47·1	34·5
30	29·777	29·827	29·909	29·996	54·1	44·9	30	29·307	29·339	29·423	29·557	45·1	37·4
31	29·906	29·800	29·678	29·577	50·5	43·5	31	29·609	29·564	29·419	29·309	43·8	38·9

FEBRUARY, 1884.

1	29·451	29·432	29·360	29·339	50·2	44·1	1	29·277	29·311	29·421	29·753	39·8	32·9
2	29·409	29·801	30·103	30·306	44·6	33·2	2	29·953	30·169	30·202	30·182	34·8	31·2
3	30·393	30·457	30·404	30·415	42·0	29·5	3	30·025	30·039	30·033	30·003	46·9	33·4
4	30·390	30·430	30·411	30·427	49·7	41·9	4	29·982	30·115	30·113	30·085	49·0	46·7
5	30·390	30·398	30·346	30·328	48·1	43·8	5	30·043	30·069	30·043	30·014	48·0	45·6
6	30·273	30·256	30·174	30·187	46·1	35·6	6	29·972	29·962	29·890	29·822	46·6	43·4
7	30·109	30·111	30·022	30·032	43·7	34·6	7	29·869	30·029	30·039	30·018	44·0	31·4
8	29·973	29·943	29·824	29·742	45·3	37·8	8	29·876	29·746	29·570	29·388	44·2	30·3
9	29·631	29·532	29·382	29·352	51·2	44·4	9	29·158	28·951	28·772	28·795	40·9	38·3
10	29·439	29·502	29·525	29·651	48·4	37·9	10	28·713	28·885	28·893	29·038	41·3	35·0
11	29·696	29·704	29·709	29·838	45·5	36·4	11	29·142	29·203	29·293	29·448	39·3	34·8
12	29·873	29·930	29·894	29·893	48·6	39·2	12	29·347	29·307	29·315	29·399	48·4	37·6
13	30·001	30·147	30·146	30·109	54·8	44·7	13	29·535	29·501	29·674	29·815	49·1	42·8
14	30·037	30·072	30·079	30·122	51·5	45·4	14	29·711	30·007	30·157	30·193	49·3	37·9
15	30·109	30·065	29·973	29·962	46·3	35·0	15	30·119	30·143	30·140	30·184	42·6	37·6
16	29·881	29·913	29·919	29·942	40·6	33·4	16	30·165	30·134	30·026	30·015	40·8	36·3
17	29·927	29·919	29·861	29·876	43·8	35·7	17	29·921	29·923	29·850	29·841	40·1	34·4
18	29·842	29·850	29·783	29·793	43·1	33·4	18	29·764	29·765	29·707	29·707	42·0	34·5
19	29·741	29·727	29·713	29·722	48·2	36·2	19	29·667	29·623	29·562	29·517	41·1	34·1
20	29·759	29·844	29·816	29·779	51·3	44·9	20	29·447	29·445	29·371	29·188	48·0	40·4
21	29·680	29·711	29·681	29·638	51·5	44·0	21	29·005	29·361	29·345	29·345	49·1	37·1
22	29·604	29·651	29·590	29·535	51·3	41·0	22	29·282	29·305	29·359	29·365	42·5	37·6
23	29·528	29·534	29·464	29·438	50·8	38·6	23	29·290	29·243	29·189	29·225	44·0	36·2
24	29·417	29·541	29·689	29·811	46·8	36·9	24	29·378	29·532	29·615	29·679	44·8	34·3
25	29·823	29·870	29·855	29·903	47·8	34·2	25	29·702	29·739	29·767	29·842	47·0	36·1
26	29·888	29·927	29·911	29·974	46·7	32·5	26	29·864	29·927	29·915	29·950	42·1	32·8
27	29·959	29·987	29·956	29·983	44·6	30·1	27	29·919	29·941	29·909	29·959	42·7	34·3
28	29·956	29·943	29·893	29·915	40·1	31·6	28	29·963	29·974	29·915	29·915	39·4	31·7
29	29·884	29·913	29·912	29·972	40·7	30·4	29	29·882	29·887	29·884	29·910	35·6	30·0

BAROMETER READINGS, &c.

MARCH, 1884.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·973	30·015	29·994	30·024	40·0	27·2	1	29·881	29·905	29·948	30·017	37·2	30·7
2	30·011	30·051	30·018	30·050	43·3	31·3	2	30·029	30·059	29·994	29·933	41·3	34·8
3	29·978	29·884	29·698	29·706	44·5	27·4	3	29·759	29·539	29·379	29·480	37·2	31·4
4	29·643	29·610	29·584	29·671	51·3	42·1	4	29·591	29·644	29·607	29·624	39·1	34·2
5	29·904	30·082	30·143	30·233	49·8	36·1	5	29·708	29·870	29·976	30·034	45·9	35·0
6	30·228	30·293	30·089	30·038	50·7	31·0	6	30·023	29·982	29·864	29·790	52·1	42·0
7	29·964	29·946	29·872	29·809	49·5	30·6	7	29·693	29·677	29·693	29·718	46·9	41·3
8	29·824	29·775	29·645	29·576	49·2	33·8	8	29·675	29·604	29·466	29·357	44·3	37·6
9	29·478	29·541	29·509	29·407	49·5	38·7	9	29·269	29·309	29·260	29·077	45·4	35·8
10	29·185	29·210	29·343	29·390	49·2	38·4	10	28·950	29·019	29·087	29·130	41·7	33·9
11	29·229	29·258	29·412	29·506	45·1	37·7	11	29·229	29·303	29·333	29·365	41·5	31·1
12	29·554	29·684	29·730	29·862	51·6	39·1	12	29·379	29·458	29·482	29·503	44·1	38·3
13	29·946	30·046	30·067	30·093	54·3	42·1	13	29·584	29·625	29·595	29·599	49·8	40·9
14	30·087	30·110	30·064	30·073	59·1	46·5	14	29·642	29·650	29·659	29·709	53·2	48·2
15	30·048	30·073	30·020	30·051	65·1	45·3	15	29·745	29·837	29·868	29·908	54·4	47·9
16	30·018	30·032	29·991	30·010	65·0	44·7	16	29·894	29·895	29·845	29·864	62·0	44·9
17	30·000	30·030	29·998	30·050	63·4	38·3	17	29·843	29·837	29·787	29·801	57·3	47·4
18	30·032	30·038	29·983	30·074	61·3	44·4	18	29·747	29·615	29·553	29·681	52·4	42·0
19	30·085	30·101	29·971	29·905	56·2	43·5	19	29·766	29·798	29·649	29·385	52·0	39·9
20	29·885	29·923	29·905	29·894	50·8	40·5	20	29·162	29·311	29·493	29·589	46·9	36·3
21	29·825	29·961	29·984	30·040	49·3	38·2	21	29·766	29·838	29·872	29·928	47·4	35·8
22	30·041	30·054	30·006	30·033	51·3	33·2	22	29·885	29·823	29·795	29·934	48·0	35·0
23	30·024	30·097	30·081	30·107	50·7	40·1	23	29·977	30·037	30·036	30·077	48·6	37·9
24	30·104	30·129	30·109	30·154	50·0	36·1	24	30·069	30·064	30·006	30·021	52·0	34·2
25	30·139	30·136	30·089	30·106	45·5	32·4	25	30·014	30·052	30·059	30·114	51·0	41·8
26	30·057	30·069	30·047	30·099	43·2	38·3	26	30·156	30·210	30·194	30·242	42·2	34·2
27	30·095	30·139	30·101	30·099	41·0	38·0	27	30·228	30·235	30·174	30·150	41·4	35·3
28	30·060	30·070	30·028	30·052	41·6	36·7	28	30·098	30·106	30·069	30·088	42·0	36·7
29	30·011	30·011	29·929	29·908	45·2	36·8	29	30·049	30·029	29·945	29·917	44·3	36·0
30	29·828	29·798	29·702	29·668	50·8	37·0	30	29·722	29·722	29·599	29·518	43·9	38·0
31	29·549	29·478	29·499	29·525	53·1	42·5	31	29·381	29·289	29·297	29·373	45·0	34·6

APRIL, 1884.

1	29·510	29·569	29·581	29·635	56·4	44·1	1	29·260	29·340	29·398	29·477	53·1	34·3
2	29·615	29·587	29·565	29·570	65·0	46·9	2	29·512	29·531	29·470	29·524	50·5	41·9
3	29·526	29·454	29·421	29·449	63·6	46·6	3	29·522	29·502	29·425	29·399	57·2	44·5
4	29·509	29·524	29·425	29·275	60·8	42·6	4	29·399	29·378	29·385	29·349	56·7	43·3
5	29·297	29·332	29·337	29·427	57·2	45·1	5	29·201	29·113	29·153	29·202	54·1	43·2
6	29·499	29·586	29·584	29·552	57·9	45·2	6	29·193	29·270	29·450	29·574	55·2	43·1
7	29·418	29·499	29·620	29·746	55·3	46·4	7	29·553	29·544	29·532	29·646	54·2	40·9
8	29·812	29·887	29·873	29·896	59·6	41·6	8	29·739	29·850	29·889	29·947	56·0	40·0
9	29·907	29·924	29·890	29·938	55·4	39·1	9	29·972	29·992	29·963	30·004	52·0	39·4
10	29·915	29·940	29·926	29·999	50·8	37·6	10	30·015	30·029	29·981	30·011	55·0	37·4
11	30·000	30·035	30·008	30·026	49·8	38·0	11	29·977	29·998	29·995	30·047	50·0	35·1
12	30·015	30·021	30·002	30·011	48·9	33·6	12	30·038	30·070	30·052	30·101	51·0	34·4
13	30·013	30·015	29·997	30·068	50·4	33·3	13	30·131	30·179	30·172	30·220	52·9	39·6
14	30·040	30·031	29·975	29·994	49·6	36·3	14	30·210	30·215	30·171	30·177	53·7	44·6
15	29·959	29·933	29·849	29·853	48·4	40·0	15	30·111	30·038	29·934	29·912	53·9	42·9
16	29·814	29·824	29·798	29·848	46·9	39·1	16	29·864	29·875	29·913	30·014	48·9	39·2
17	29·857	29·924	29·935	29·991	43·6	36·1	17	30·064	30·140	30·128	30·166	49·3	38·0
18	29·969	29·954	29·864	29·858	44·0	34·2	18	30·105	30·037	29·931	29·885	46·5	38·1
19	29·816	29·835	29·828	29·887	44·1	34·1	19	29·831	29·848	29·838	29·883	52·3	40·4
20	29·900	29·931	29·918	29·940	44·5	34·3	20	29·904	29·939	29·933	29·987	50·1	41·9
21	29·927	29·934	29·933	29·992	47·8	30·8	21	29·983	30·002	29·989	30·020	49·4	39·1
22	29·974	29·986	29·962	29·999	47·1	31·8	22	30·010	29·993	29·972	29·950	44·5	38·9
23	29·970	29·943	29·869	29·882	48·6	28·1	23	29·898	29·889	29·858	29·861	42·2	39·1
24	29·840	29·813	29·757	29·802	47·5	29·6	24	29·854	29·856	29·836	29·880	45·3	38·0
25	29·802	29·831	29·830	29·852	47·4	33·6	25	29·877	29·877	29·839	29·814	46·6	36·9
26	29·823	29·806	29·754	29·724	50·4	38·4	26	29·749	29·698	29·655	29·664	48·1	33·9
27	29·670	29·638	29·576	29·661	48·5	34·3	27	29·671	29·735	29·764	29·886	52·8	33·9
28	29·664	29·716	29·735	29·769	52·4	35·1	28	29·930	29·960	29·914	29·897	50·9	35·2
29	29·744	29·758	29·716	29·736	59·0	30·5	29	29·806	29·747	29·646	29·574	51·7	40·3
30	29·713	29·733	29·707	29·833	56·2	37·1	30	29·466	29·472	29·552	29·636	49·4	40·2

BAROMETER READINGS, &c.

MAY, 1884.

	KEW.						GLASGOW.					
	Barometer.				Temperature.		Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·888	29·874	29·760	29·671	54·3	35·5	1	29·547	29·272	29·263	29·305	46·8	36·5
2	29·683	29·737	29·620	29·578	54·7	46·4	2	29·323	29·321	29·248	29·252	48·8	37·1
3	29·456	29·396	29·361	29·329	56·0	42·0	3	29·091	29·023	28·887	28·871	45·9	36·0
4	29·338	29·380	29·357	29·404	55·0	41·1	4	28·868	28·930	29·059	29·188	52·3	36·1
5	29·389	29·455	29·511	29·593	55·5	38·8	5	29·203	29·293	29·371	29·490	53·2	35·7
6	29·625	29·744	29·814	29·949	57·6	37·2	6	29·555	29·663	29·729	29·829	51·0	37·3
7	30·005	30·046	30·007	29·946	56·1	37·0	7	29·837	29·787	29·555	29·462	48·6	35·2
8	29·965	30·026	30·078	30·126	59·1	46·5	8	29·421	29·570	29·642	29·715	52·0	43·3
9	30·137	30·175	30·171	30·219	64·6	48·1	9	29·679	29·756	29·855	29·957	59·1	46·0
10	30·215	30·226	30·149	30·145	71·5	44·3	10	29·984	30·006	29·993	30·015	56·0	47·1
11	30·083	30·055	29·960	29·957	75·6	45·5	11	29·960	29·895	29·744	29·792	68·7	48·0
12	29·956	29·966	29·862	29·907	73·1	48·2	12	29·826	29·897	29·891	29·910	58·3	46·8
13	29·948	29·975	29·866	29·855	68·1	50·4	13	29·880	29·848	29·725	29·600	56·0	41·6
14	29·787	29·805	29·867	30·036	60·2	46·3	14	29·476	29·548	29·748	29·831	56·5	45·2
15	30·082	30·090	30·047	30·060	59·5	47·4	15	29·732	29·644	29·664	29·685	56·8	43·7
16	30·022	30·027	29·978	29·961	67·2	53·3	16	29·629	29·650	29·607	29·551	55·9	47·5
17	29·868	29·870	29·677	29·694	71·5	51·3	17	29·499	29·446	29·349	29·417	56·7	43·2
18	29·736	29·820	29·828	29·846	63·0	47·3	18	29·490	29·607	29·694	29·770	53·4	40·8
19	29·834	29·861	29·856	29·911	58·2	45·2	19	29·791	29·815	29·833	29·884	51·5	37·1
20	29·944	30·058	30·114	30·250	63·2	43·3	20	29·916	29·974	30·020	30·133	53·3	36·9
21	30·345	30·410	30·362	30·398	67·6	37·2	21	30·175	30·215	30·201	30·186	54·6	41·0
22	*30·411	30·401	30·328	30·308	67·8	39·5	22	30·207	30·295	30·282	30·286	66·0	49·6
23	30·238	30·198	30·096	30·082	73·7	47·9	23	30·262	30·231	30·149	30·132	70·3	44·0
24	30·023	30·004	29·966	30·018	76·7	48·6	24	30·143	30·124	30·091	30·144	64·6	46·5
25	30·032	30·070	30·076	30·136	56·4	49·6	25	30·154	30·167	30·153	30·210	56·6	43·3
26	30·168	30·192	30·230	30·289	64·8	46·4	26	30·252	30·266	30·260	30·310	59·2	41·9
27	30·283	30·255	30·183	30·210	65·7	42·3	27	30·313	30·280	30·231	30·274	64·6	41·0
28	30·211	30·224	30·193	30·197	53·3	42·4	28	30·270	30·270	30·239	30·293	61·9	42·2
29	30·179	30·173	30·118	30·104	53·2	45·6	29	30·273	30·273	30·211	30·201	57·5	46·9
30	30·051	30·015	29·951	30·011	64·2	43·6	30	30·153	30·120	30·062	30·090	57·1	46·7
31	30·614	30·038	30·039	30·073	56·1	42·8	31	30·094	30·111	30·049	30·001	63·1	46·0

* Approximate.

JUNE, 1884.

1	30·033	29·960	29·803	29·735	65·2	40·9	1	29·872	29·671	29·490	29·421	58·9	44·6
2	29·659	29·622	29·565	29·571	69·0	45·9	2	29·416	29·516	29·593	29·653	55·7	48·2
3	29·519	29·531	29·573	29·635	62·1	48·6	3	29·688	29·705	29·690	29·720	63·1	47·2
4	29·664	29·736	29·750	29·768	59·1	50·6	4	29·735	29·739	29·747	29·764	60·9	45·4
5	29·748	29·786	29·788	29·777	61·2	48·1	5	29·731	29·734	29·689	29·645	48·5	45·8
6	29·729	29·736	29·683	29·633	58·7	47·6	6	29·592	29·594	29·607	29·629	51·4	44·9
7	29·491	29·515	29·567	29·661	57·1	46·3	7	29·630	29·653	29·667	29·741	59·5	48·8
8	29·695	29·760	29·775	29·796	58·8	47·0	8	29·738	29·763	29·770	29·828	58·6	45·0
9	29·799	29·843	29·880	29·959	57·7	45·5	9	29·858	29·899	29·913	29·945	56·0	39·9
10	30·004	30·064	30·080	30·126	62·7	48·4	10	29·961	29·976	29·969	29·962	61·5	43·3
11	30·132	30·150	30·156	30·190	64·0	46·7	11	29·884	29·886	29·953	30·067	61·3	49·3
12	30·225	30·271	30·271	30·295	72·6	54·6	12	30·140	30·200	30·211	30·181	62·2	45·9
13	30·293	30·264	30·170	30·140	77·3	52·0	13	30·111	30·056	30·169	30·250	63·7	44·9
14	30·172	30·213	30·218	30·278	66·1	51·7	14	30·250	30·268	30·277	30·296	57·2	44·6
15	30·278	30·268	30·213	30·230	62·8	48·9	15	30·273	30·263	30·241	30·235	60·8	46·0
16	30·206	30·169	30·135	30·155	62·3	51·3	16	30·214	30·191	30·144	30·151	61·2	43·3
17	30·142	30·154	30·126	30·149	58·7	49·6	17	30·129	30·139	30·112	30·150	69·0	50·1
18	30·162	30·175	30·159	30·192	61·8	49·1	18	30·148	30·155	30·143	30·175	61·2	48·1
19	30·201	30·213	30·180	30·193	68·7	54·5	19	30·179	30·184	30·168	30·196	62·5	44·7
20	30·177	30·194	30·164	30·170	67·6	54·0	20	30·194	30·190	30·179	30·184	62·7	50·0
21	30·159	30·184	30·154	30·159	67·6	51·8	21	30·153	30·153	30·117	30·132	66·5	44·8
22	30·137	30·123	30·075	30·093	69·6	51·0	22	30·106	30·081	30·034	30·053	64·9	47·2
23	30·036	30·028	29·983	29·982	66·8	52·0	23	30·026	30·010	29·957	29·905	61·3	44·2
24	29·971	29·965	29·905	29·908	71·1	49·6	24	29·797	29·741	29·645	29·713	58·6	49·1
25	29·912	29·993	30·023	30·107	72·4	55·8	25	29·808	29·908	29·953	29·972	59·2	49·0
26	30·139	30·152	30·090	30·109	78·1	47·1	26	29·932	29·984	29·983	30·018	66·5	52·0
27	30·094	30·110	30·089	30·157	80·0	52·8	27	30·042	30·099	30·120	30·151	73·5	56·5
28	30·168	30·179	30·144	30·111	77·1	56·1	28	30·159	30·168	30·112	30·075	81·1	51·8
29	30·032	29·968	29·947	30·063	72·3	55·5	29	30·127	29·941	29·908	29·944	70·2	56·4
30	30·029	30·074	30·062	30·129	73·2	51·4	30	29·946	29·976	29·979	30·045	66·6	54·9

BAROMETER READINGS, &c.

JULY, 1884.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·162	30·180	30·155	30·179	75·1	55·0	1	30·080	30·118	30·096	30·122	67·8	52·9
2	30·164	30·140	30·060	30·062	77·8	51·7	2	30·115	30·050	30·032	30·029	71·0	54·4
3	30·013	29·960	29·904	29·915	83·0	53·0	3	29·982	29·972	29·893	29·898	71·2	53·0
4	29·887	29·886	29·824	29·897	85·6	55·7	4	29·882	29·923	29·857	29·833	66·6	55·0
5	29·880	29·903	29·893	29·915	74·7	57·8	5	29·826	29·862	29·832	29·833	66·1	53·9
6	29·903	29·926	29·946	29·982	68·7	54·6	6	29·794	29·801	29·785	29·814	68·4	56·0
7	29·979	29·967	29·911	29·910	75·9	56·4	7	29·791	29·772	29·776	29·801	65·1	53·2
8	29·881	29·870	29·826	29·863	82·7	56·1	8	29·779	29·836	29·826	29·812	69·7	57·5
9	29·828	29·778	29·703	29·698	78·0	58·8	9	29·786	29·792	29·726	29·682	71·6	58·1
10	29·623	29·601	29·584	29·656	73·1	55·6	10	29·596	29·562	29·511	29·504	68·1	58·5
11	29·700	29·741	29·742	29·761	69·5	53·9	11	29·478	29·525	29·549	29·569	65·6	53·3
12	29·797	29·851	29·863	29·891	67·2	56·6	12	29·546	29·646	29·701	29·730	67·7	54·2
13	29·885	29·859	*29·813	29·871	81·5	57·7	13	29·731	29·722	29·642	29·622	69·9	53·3
14	29·927	29·929	29·908	29·931	71·3	54·0	14	29·611	29·591	29·596	29·623	64·9	54·8
15	29·915	29·906	29·860	29·776	69·9	57·0	15	29·656	29·674	29·592	29·436	65·9	54·3
16	29·664	29·665	29·677	29·715	69·6	55·6	16	29·338	29·286	29·294	29·310	61·1	55·4
17	29·722	29·725	29·780	29·914	69·8	54·5	17	29·330	29·426	29·544	29·621	61·0	40·8
18	29·970	30·013	30·027	30·049	66·7	51·5	18	29·624	29·683	29·752	29·835	59·6	49·2
19	30·053	30·100	30·121	30·137	67·0	49·2	19	29·898	29·972	29·996	30·042	60·5	43·9
20	30·099	30·090	30·052	30·051	68·9	47·7	20	30·027	30·022	29·966	29·920	63·9	43·1
21	29·971	29·902	29·825	29·918	68·7	55·9	21	29·825	29·754	29·754	29·780	54·4	51·2
22	29·967	29·982	29·956	29·963	70·4	55·6	22	29·754	29·744	29·738	29·686	61·5	50·6
23	29·912	29·862	29·749	29·727	69·4	53·5	23	29·583	29·516	29·447	29·439	63·2	52·7
24	29·723	29·715	29·705	29·753	65·7	49·8	24	29·408	29·412	29·487	29·657	58·9	48·4
25	29·812	29·918	30·004	30·101	64·1	47·8	25	29·752	29·843	29·888	29·930	60·0	45·1
26	30·124	30·119	30·015	29·889	63·3	43·4	26	29·878	29·822	29·735	29·703	55·5	44·8
27	30·161	30·161	30·119	30·115	66·3	54·8	27	29·701	29·804	29·879	29·949	63·8	50·0
28	30·078	30·057	29·984	29·969	68·7	53·3	28	29·956	29·937	29·879	29·883	60·1	47·1
29	29·912	29·899	29·920	30·006	68·6	55·8	29	29·880	29·937	29·985	30·026	60·3	52·6
30	29·775	29·778	29·809	29·955	73·4	61·3	30	30·015	30·027	29·989	29·992	65·7	52·5
31	30·127	30·173	30·153	30·173	76·2	56·6	31	29·990	30·024	30·035	30·036	65·8	54·2

* Approximate.

AUGUST, 1884.

1	30·077	30·056	29·986	29·971	80·8	56·7	1	30·001	29·964	29·832	29·734	68·1	53·4
2	29·914	29·902	29·919	30·005	76·1	57·6	2	29·632	29·642	29·658	29·710	62·7	53·9
3	30·019	30·051	30·053	30·106	69·2	53·6	3	29·712	29·746	29·775	29·856	61·1	52·5
4	30·155	30·194	30·197	30·234	71·7	50·4	4	29·927	29·984	30·043	30·071	60·5	51·0
5	30·224	30·227	30·160	30·172	75·1	47·3	5	30·061	30·049	30·005	30·002	63·0	51·1
6	30·125	30·116	30·040	30·050	76·0	49·5	6	29·973	29·978	29·944	29·946	72·0	51·1
7	30·001	30·021	29·983	30·043	82·5	53·7	7	29·940	29·969	29·960	30·002	75·4	55·9
8	30·028	30·028	29·987	30·019	*86·9	57·8	8	30·008	30·010	29·941	29·933	72·3	55·2
9	29·978	29·971	29·936	29·978	84·2	59·4	9	29·921	29·906	29·847	29·867	72·3	57·3
10	29·932	29·972	29·908	29·920	80·7	60·0	10	29·846	29·842	29·781	29·772	65·6	55·5
11	29·882	29·907	29·876	29·902	89·2	59·9	11	29·773	29·800	29·774	29·802	74·4	60·9
12	29·890	29·909	29·898	29·944	79·6	62·2	12	29·787	29·771	29·764	29·758	64·8	57·8
13	29·959	29·969	29·933	29·948	76·0	59·9	13	29·731	29·712	29·726	29·750	68·0	57·3
14	29·934	29·965	29·973	30·047	71·3	57·2	14	29·740	29·786	29·824	29·881	64·0	53·0
15	30·063	30·120	30·092	30·123	74·8	51·9	15	29·881	29·910	29·882	29·844	63·7	53·4
16	30·110	30·114	30·024	30·034	78·6	50·9	16	29·817	29·849	29·848	29·846	62·8	58·1
17	29·991	29·967	29·900	29·922	82·1	51·5	17	29·799	29·835	29·817	29·835	67·9	56·4
18	29·891	29·897	29·859	29·889	79·0	52·0	18	29·800	29·780	29·706	29·677	72·0	56·0
19	29·872	29·873	29·833	29·897	70·1	52·4	19	29·646	29·600	29·691	29·814	63·2	49·0
20	29·951	30·022	30·022	30·091	72·0	49·6	20	29·850	29·912	29·890	29·898	64·3	45·0
21	30·127	30·178	30·141	30·179	77·1	53·1	21	29·945	30·074	30·075	30·081	65·0	52·0
22	30·159	30·161	30·072	30·091	78·3	52·3	22	30·019	30·021	29·976	29·965	67·6	53·6
23	30·073	30·087	30·035	30·067	80·4	54·9	23	29·935	29·926	29·898	29·886	74·0	54·0
24	30·052	30·050	29·971	29·965	84·1	53·9	24	29·869	29·840	29·833	29·858	61·8	54·1
25	29·932	29·960	30·017	30·082	65·8	50·4	25	29·898	29·955	29·998	30·058	59·2	45·0
26	30·100	30·114	30·063	30·027	59·9	46·6	26	30·016	29·979	29·917	29·906	53·0	46·0
27	29·960	29·911	29·836	29·780	58·1	49·3	27	29·847	29·785	29·669	29·572	53·6	46·5
28	29·658	29·645	29·634	29·650	67·0	53·2	28	29·436	29·390	29·360	29·308	57·7	45·1
29	29·624	29·687	29·772	29·870	63·8	51·1	29	29·402	29·463	29·510	29·557	57·9	43·1
30	29·875	29·864	29·806	29·828	67·7	53·0	30	29·574	29·594	29·562	29·553	60·0	47·6
31	29·784	29·774	29·713	29·682	66·9	60·0	31	29·550	29·555	29·512	29·488	58·0	45·4

* Approximate.

BAROMETER READINGS, &c.

SEPTEMBER, 1884.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·613	29·626	29·629	29·709	66·5	56·9	1	29·430	29·415	29·363	29·381	60·6	40·8
2	29·696	29·718	29·692	29·736	66·1	50·2	2	29·382	29·394	29·391	29·461	59·8	44·8
3	29·700	29·685	29·594	29·537	67·2	47·3	3	29·472	29·494	29·481	29·507	60·6	45·7
4	29·388	29·412	29·441	29·518	61·2	49·2	4	29·487	29·491	29·431	29·457	61·0	45·2
5	29·525	29·583	29·614	29·698	64·6	47·5	5	29·417	29·420	29·404	29·442	60·2	44·3
6	29·702	29·653	29·508	29·403	62·5	44·0	6	29·432	29·404	29·285	29·168	58·8	43·1
7	29·407	29·551	29·683	29·971	63·1	52·0	7	29·184	29·401	29·570	29·705	59·6	48·7
8	30·031	30·121	30·115	30·122	61·3	51·9	8	29·789	29·863	29·872	29·883	61·5	47·3
9	30·132	30·184	30·159	30·181	68·1	56·7	9	29·890	29·958	29·989	30·033	65·8	54·7
10	30·167	30·210	30·201	30·255	68·2	51·9	10	30·038	30·083	30·068	30·105	67·2	60·7
11	30·249	30·306	30·268	30·302	70·1	50·6	11	30·133	30·219	30·247	30·299	68·6	56·1
12	30·286	30·289	30·212	30·238	70·0	55·2	12	30·326	30·364	30·315	30·390	65·6	49·0
13	30·211	30·202	30·113	30·094	72·4	55·9	13	30·376	30·361	30·289	30·301	64·3	48·7
14	30·069	30·038	30·004	29·998	70·1	56·5	14	30·261	30·249	30·190	30·171	59·0	50·0
15	29·975	29·997	29·971	29·969	73·8	56·9	15	30·115	30·104	30·078	30·094	56·7	51·5
16	29·991	30·091	30·120	30·168	74·8	61·1	16	30·033	30·036	30·004	30·086	60·0	53·7
17	30·174	30·224	30·216	30·296	80·0	60·0	17	30·099	30·158	30·173	30·272	69·0	54·3
18	30·308	30·350	30·293	30·323	76·8	56·6	18	30·289	30·316	30·275	30·262	65·3	54·0
19	30·271	30·284	30·178	30·175	65·2	55·1	19	30·210	30·177	30·121	30·080	62·7	51·3
20	30·130	30·097	29·979	29·922	68·9	54·6	20	29·971	29·951	29·848	29·734	62·4	53·0
21	29·793	29·729	29·664	29·626	69·5	52·0	21	29·599	29·589	29·368	29·389	61·1	49·0
22	29·621	29·776	29·832	29·978	63·0	50·7	22	29·405	29·466	29·533	29·680	55·8	45·5
23	30·072	30·174	30·184	30·229	59·8	47·4	23	29·750	29·866	29·871	29·827	55·1	45·1
24	30·195	30·180	30·080	30·113	62·0	49·2	24	29·680	29·651	29·632	29·737	56·9	50·5
25	30·112	30·166	30·087	30·072	63·3	46·8	25	29·832	29·873	29·749	29·604	57·0	48·8
26	29·977	29·944	29·896	29·915	63·8	47·6	26	29·518	29·576	29·598	29·541	56·1	48·0
27	29·929	29·918	29·907	29·986	60·1	46·8	27	29·285	29·259	29·489	29·532	57·9	48·7
28	30·008	30·058	30·034	30·034	65·5	53·1	28	29·491	29·618	29·516	29·490	57·5	48·0
29	30·000	30·058	30·108	30·171	63·0	47·6	29	29·643	29·763	29·825	29·885	53·9	45·0
30	30·180	30·175	30·076	30·044	61·5	40·6	30	29·855	29·795	29·623	29·511	56·8	45·6

OCTOBER, 1884.

1	29·971	30·004	30·045	30·121	60·1	45·5	1	29·530	29·716	29·838	29·887	53·8	44·3
2	30·096	30·049	29·919	29·882	61·7	40·0	2	29·805	29·725	29·568	29·512	57·2	44·3
3	29·910	30·050	30·135	30·273	59·5	44·2	3	29·596	29·771	29·911	30·085	53·0	44·8
4	30·357	30·456	30·516	30·608	57·1	39·3	4	30·234	30·371	30·358	30·512	55·4	43·0
5	30·619	30·637	30·569	30·544	55·8	37·3	5	30·535	30·597	30·575	30·577	56·0	47·0
6	30·484	30·442	30·326	30·301	59·4	48·7	6	30·535	30·494	30·380	30·350	58·9	44·8
7	30·207	30·144	30·029	29·966	61·5	50·7	7	30·276	30·184	30·036	29·903	51·8	40·4
8	29·882	29·798	29·647	29·603	58·1	41·5	8	29·678	29·494	29·365	29·327	49·4	40·8
9	29·551	29·473	29·364	29·336	53·9	35·4	9	29·317	29·368	29·385	29·479	45·8	35·9
10	29·339	29·416	29·485	29·504	46·2	39·1	10	29·468	29·485	29·522	29·572	45·9	34·0
11	29·555	29·652	29·659	29·675	46·6	38·2	11	29·553	29·549	29·571	29·707	48·9	34·0
12	29·687	29·776	29·837	29·923	49·5	40·3	12	29·791	29·864	29·879	29·941	48·4	37·7
13	29·977	30·061	30·047	30·089	49·3	36·1	13	29·914	29·907	29·833	29·802	46·4	36·0
14	30·045	30·066	30·048	30·183	56·6	37·2	14	29·801	29·904	29·936	29·985	52·9	46·0
15	30·213	30·263	30·216	30·247	56·1	43·1	15	29·848	29·876	29·912	30·013	55·9	43·8
16	30·230	30·316	30·312	30·344	62·4	51·0	16	30·041	30·037	29·999	30·016	56·1	45·8
17	30·297	30·333	30·287	30·310	58·8	53·0	17	30·023	30·045	30·041	30·085	56·1	51·5
18	30·322	30·366	30·318	30·351	57·2	47·2	18	30·109	30·151	30·105	30·048	56·6	50·8
19	30·309	30·303	30·255	30·280	60·2	45·1	19	30·024	30·076	30·067	30·101	54·5	47·3
20	30·301	30·339	30·336	30·365	51·7	44·1	20	30·113	30·143	30·138	30·139	53·0	46·0
21	30·341	30·347	30·269	30·267	53·0	43·8	21	30·091	30·082	30·034	30·037	55·6	50·9
22	30·215	30·194	30·115	30·075	57·8	43·2	22	30·002	29·991	29·922	29·880	54·8	50·0
23	29·993	29·949	29·873	29·865	53·3	35·5	23	29·787	29·747	29·697	29·709	54·4	48·7
24	29·843	29·892	29·916	30·017	51·7	35·4	24	29·716	29·810	29·850	29·906	49·5	40·9
25	30·044	30·088	29·986	29·884	51·4	34·5	25	29·811	29·688	29·480	29·144	54·6	41·0
26	29·654	29·563	29·636	29·659	56·2	44·2	26	29·061	29·157	29·180	29·246	53·9	37·2
27	29·726	29·854	29·878	29·715	54·1	41·3	27	29·413	29·525	29·414	29·044	51·3	37·0
28	29·551	29·508	29·631	29·826	60·8	38·1	28	28·840	29·079	29·356	29·524	51·9	35·8
29	29·930	30·054	30·089	30·142	50·4	33·9	29	29·594	29·664	29·682	29·670	47·0	35·2
30	30·168	30·224	30·205	30·237	53·1	36·0	30	29·688	29·682	29·587	29·623	56·6	45·1
31	30·231	30·264	30·213	30·215	56·0	42·2	31	29·605	29·621	29·684	29·665	56·4	48·1

BAROMETER READINGS, &c.

NOVEMBER, 1884.

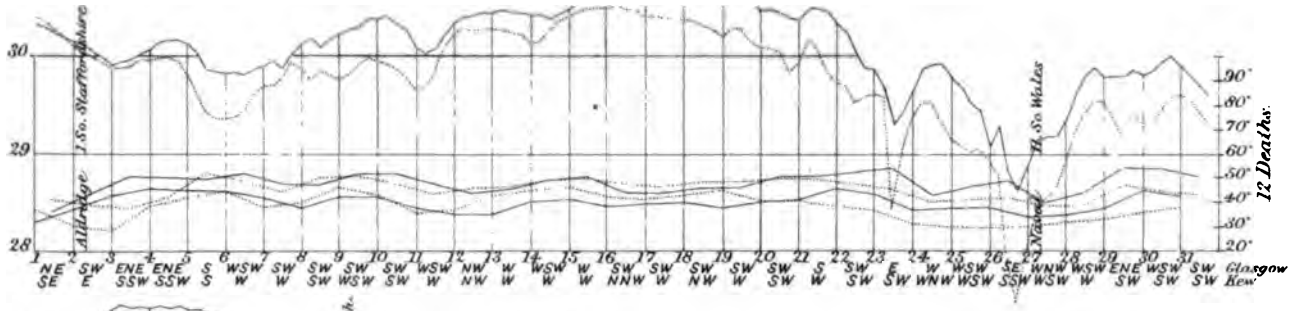
KEW.							GLASGOW.						
	BAROMETER.				TEMPERATURE.			BAROMETER.				TEMPERATURE.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·147	30·121	30·033	29·995	54·5	42·3	1	29·643	29·588	29·694	29·658	55·2	46·8
2	29·921	29·883	29·831	29·948	59·2	44·0	2	29·512	29·617	29·674	29·734	46·9	39·8
3	29·985	30·074	30·072	30·081	48·6	33·1	3	29·697	29·772	29·822	29·794	46·4	38·9
4	29·975	29·884	29·861	29·788	56·3	35·7	4	29·653	29·486	29·259	29·067	53·3	42·9
5	29·790	29·892	29·913	29·910	59·1	50·3	5	29·080	29·172	29·309	29·491	51·0	43·5
6	29·963	30·016	29·964	29·932	56·4	48·3	6	29·590	29·728	29·766	29·710	47·7	42·0
7	29·837	29·790	29·773	30·041	58·6	42·6	7	29·368	29·230	29·255	29·676	55·8	39·1
8	30·228	30·347	30·297	30·288	52·3	34·5	8	29·795	29·745	29·664	29·653	51·2	39·7
9	30·224	30·255	30·260	30·346	54·7	48·0	9	29·537	29·783	29·916	30·059	52·0	43·9
10	30·427	30·520	30·486	30·477	53·8	46·4	10	30·189	30·297	30·267	30·231	50·1	42·1
11	30·432	30·398	30·331	30·325	49·6	43·1	11	30·141	30·132	30·091	30·084	51·4	47·5
12	30·270	30·273	30·250	30·276	48·9	45·2	12	30·005	29·963	29·939	30·066	49·9	44·1
13	30·282	30·338	30·342	30·394	47·5	44·6	13	30·189	30·326	30·368	30·450	47·1	34·0
14	30·399	30·449	30·424	30·434	45·9	36·4	14	30·449	30·461	30·376	30·354	41·7	28·4
15	30·415	30·425	30·373	30·366	42·5	32·8	15	30·336	30·333	30·2?8	30·276	41·4	32·3
16	30·328	30·315	30·251	30·251	39·3	32·7	16	30·235	30·219	30·163	30·170	37·0	31·2
17	30·236	30·260	30·225	30·247	42·4	35·1	17	30·169	30·234	30·247	30·300	39·9	29·2
18	30·266	30·292	30·314	30·372	44·1	34·7	18	30·334	30·405	30·442	30·503	41·9	35·0
19	30·424	30·450	30·455	30·435	45·0	36·7	19	30·489	30·486	30·405	30·444	42·1	31·2
20	30·309	30·144	29·915	29·839	45·1	35·9	20	30·142	29·969	30·035	30·012	46·3	34·3
21	29·729	29·769	29·880	30·031	43·4	35·4	21	30·090	30·152	30·189	30·215	43·9	32·7
22	30·086	30·139	30·098	30·085	41·6	32·4	22	30·185	30·160	30·073	30·092	42·7	30·8
23	30·081	30·117	30·112	30·131	41·9	29·2	23	30·082	30·087	30·042	30·033	38·9	33·2
24	30·087	30·092	30·112	30·172	37·2	29·6	24	30·037	30·092	30·086	30·093	38·2	29·0
25	30·202	30·242	30·231	30·246	35·4	25·9	25	30·072	30·095	30·109	30·135	44·0	36·1
26	30·242	30·261	30·231	30·245	43·2	31·2	26	30·088	30·100	30·068	29·983	46·7	37·6
27	30·195	30·136	29·991	29·877	47·8	37·0	27	29·836	29·658	29·565	29·566	49·1	41·1
28	29·826	29·777	29·694	29·729	46·5	33·3	28	29·533	29·567	29·646	29·674	42·5	35·0
29	29·717	29·742	29·811	29·949	38·2	31·1	29	29·676	29·765	29·839	29·883	36·4	26·8
30	30·016	30·034	29·937	29·872	36·7	30·1	30	29·800	29·743	29·714	29·802	33·1	26·0

DECEMBER, 1884.

1	29·824	29·826	29·846	29·901	38·3	34·1	1	29·814	29·824	29·766	29·687	36·5	25·9
2	29·861	29·779	29·574	29·639	49·2	33·2	2	29·468	29·271	29·335	29·340	45·1	36·3
3	29·516	29·390	29·370	29·425	55·0	42·2	3	29·006	28·841	28·996	29·095	46·1	37·6
4	29·330	29·213	29·325	29·638	50·7	39·1	4	29·029	28·977	29·163	29·233	39·3	35·0
5	29·698	29·752	29·816	29·810	48·2	37·8	5	29·266	29·464	29·488	29·230	48·0	34·1
6	29·688	29·684	29·674	29·727	54·0	47·9	6	29·182	29·228	29·189	29·231	48·5	38·5
7	29·813	29·911	29·857	29·746	54·3	46·1	7	29·264	29·254	29·216	29·173	46·9	38·8
8	29·693	29·790	29·801	29·939	54·1	42·2	8	29·153	29·347	29·412	29·543	42·4	37·0
9	29·936	29·910	29·886	30·063	42·5	36·2	9	29·575	29·617	29·641	29·741	41·1	35·8
10	30·139	30·074	29·847	29·654	51·5	35·1	10	29·678	29·435	29·161	29·127	48·1	39·5
11	29·630	29·628	29·471	29·635	51·0	45·1	11	29·132	29·164	29·278	29·630	47·0	41·0
12	29·910	30·108	30·122	30·107	50·5	41·1	12	29·812	29·799	29·623	29·660	50·0	38·4
13	30·091	30·134	30·123	30·121	54·3	51·1	13	29·673	29·704	29·783	29·636	52·0	45·0
14	30·041	29·966	29·823	29·901	52·8	41·2	14	29·446	29·340	29·356	29·398	52·3	35·7
15	29·813	29·741	29·769	29·887	49·2	36·0	15	29·401	29·377	29·405	29·508	39·1	33·9
16	29·989	30·057	29·931	29·785	42·8	32·7	16	29·561	29·555	29·496	29·415	40·2	32·9
17	29·567	29·587	29·706	29·891	42·9	33·2	17	29·357	29·411	29·511	29·651	35·9	29·8
18	30·004	29·938	29·656	29·609	49·3	31·7	18	29·587	29·295	29·152	29·126	40·2	33·2
19	29·438	29·553	29·511	29·355	46·2	39·4	19	29·056	28·988	29·023	28·914	43·1	35·7
20	28·830	28·893	29·274	29·576	47·1	36·6	20	28·890	29·175	29·487	29·797	42·3	36·1
21	29·784	29·990	30·058	30·136	41·2	37·1	21	29·986	30·138	30·232	30·318	39·9	29·5
22	30·140	30·213	30·180	30·182	42·5	37·2	22	30·321	30·320	30·257	30·221	31·2	24·6
23	30·118	30·074	30·015	30·014	38·5	34·2	23	30·133	30·122	30·099	30·120	35·7	25·8
24	30·039	30·088	30·090	30·097	37·7	34·1	24	30·095	30·097	30·054	30·101	41·2	30·2
25	30·020	29·984	29·921	30·008	40·1	32·7	25	30·103	30·129	30·125	30·137	38·9	29·4
26	30·036	30·076	30·076	30·124	37·2	34·1	26	30·097	30·064	30·035	30·070	39·5	29·5
27	30·144	30·197	30·167	30·152	37·7	34·5	27	30·081	30·111	30·083	30·068	40·2	35·4
28	30·087	30·031	29·919	29·879	37·6	36·2	28	30·037	30·015	29·920	29·887	38·0	32·3
29	29·800	29·783	29·756	29·801	37·2	34·2	29	29·815	29·773	29·741	29·786	37·4	28·0
30	29·829	29·913	29·957	30·058	35·8	29·8	30	29·813	29·858	29·860	29·886	36·0	33·2
31	30·093	30·170	30·212	30·288	42·3	26·9	31	29·883	29·937	29·956	30·030	40·3	33·1

1884.

JANUARY.



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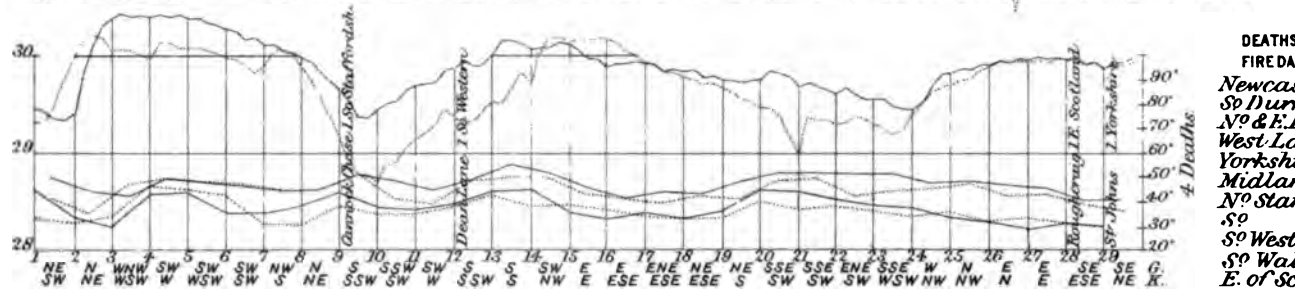

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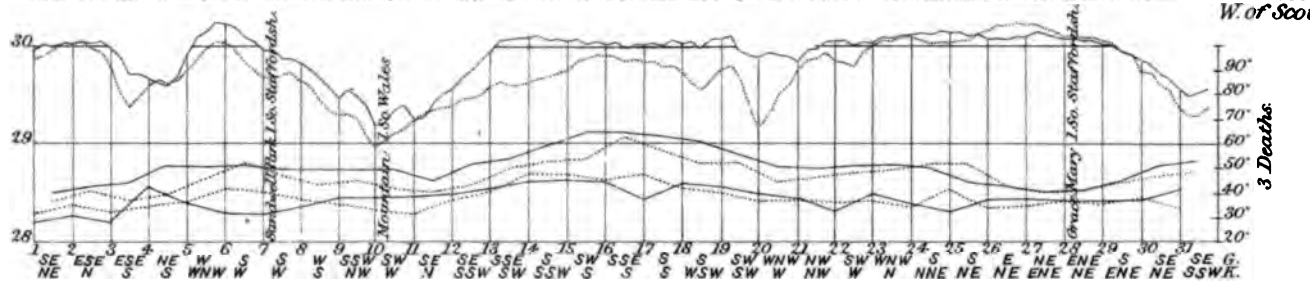


The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.
Kew lines are firm, Glasgow " dotted.
The figures attached to the districts show the No of deaths caused by the explosions.

DEATHS FROM EXPLOSIONS OF FIRE DAMP DURING THE YEAR 1884.

Newcastle	0
So Durham	0
No & E. Lancashire	0
West Lancashire	4
Yorkshire	1
Midland	1
No Staffordshire	3
So do.	16
So Western	16
So Wales	18
E. of Scotland	3
W. of Scotland	3
	65

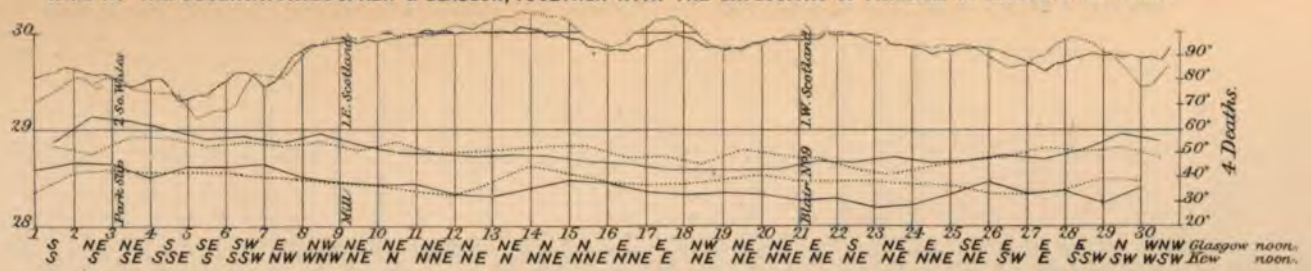
Diagrams No ET 35 M.E. 1884-85.

Andrew Reid, Newcastle

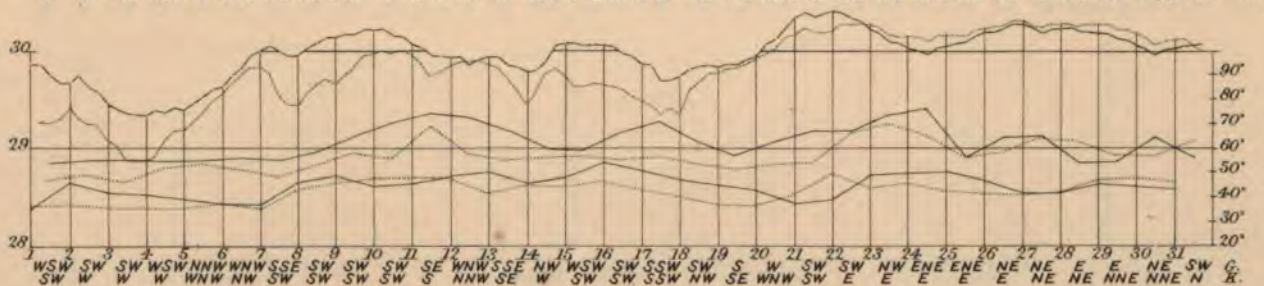
DIAGRAM SHEWING THE HEICHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES of KEW & GLASGOW, TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1884.

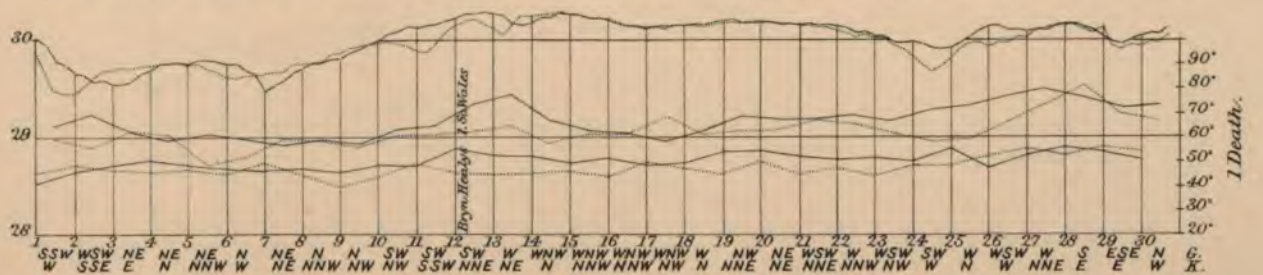
APRIL.


30
29
28
90°
80°
70°
60°
50°
40°
30°
20°
4 Deaths.
2 Sa. Wales
Park Slip
1 E. Scotland
Mill
1 W. Scotland
Pilot No 9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
S NE NE S SE SW E NW NE NE NE N NE N E E NW NE NE E S NE E E E N WNW Glasgow noon.
S S SE SSE S SSW NW WNW NE N NNE NE N NNE NNE NNE E NE NE NNE NE NE NE NNE NE SW E SSW SW WSW Kew noon.

MAY.


30
29
28
90°
80°
70°
60°
50°
40°
30°
20°
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 G.
WSW SW SW SW WSW WNW WNW SSE SW SW SW SE WNW SSE NW WSW SW SSW SW S W SW SW NW ENE ENE NE NE E E NE SW K.
SW W W W WNW NW SW SW SW SW S NNW SE W SW SW SSW NW SE WNW SW E E E E E NE NE NNE NNE N

JUNE.


30
29
28
90°
80°
70°
60°
50°
40°
30°
20°
1 Death.
1 S. Wales
Bryn Hendy
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
SSW WSW NE NE NE N NE N N SW SW SW W WNW WNW WNW WNW W NW NE WSW W WSW SW W WSW W S ESE N G.
W SSE E N NNW W NE NNW NW NW SSW NNE NE N NNW NNW NW N NNE NE NNE NNW NW W N W NNE E E W K.

The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.
Kew lines are firm, Glasgow – dotted.
The figures attached to the districts shew the No of deaths caused by the explosions.

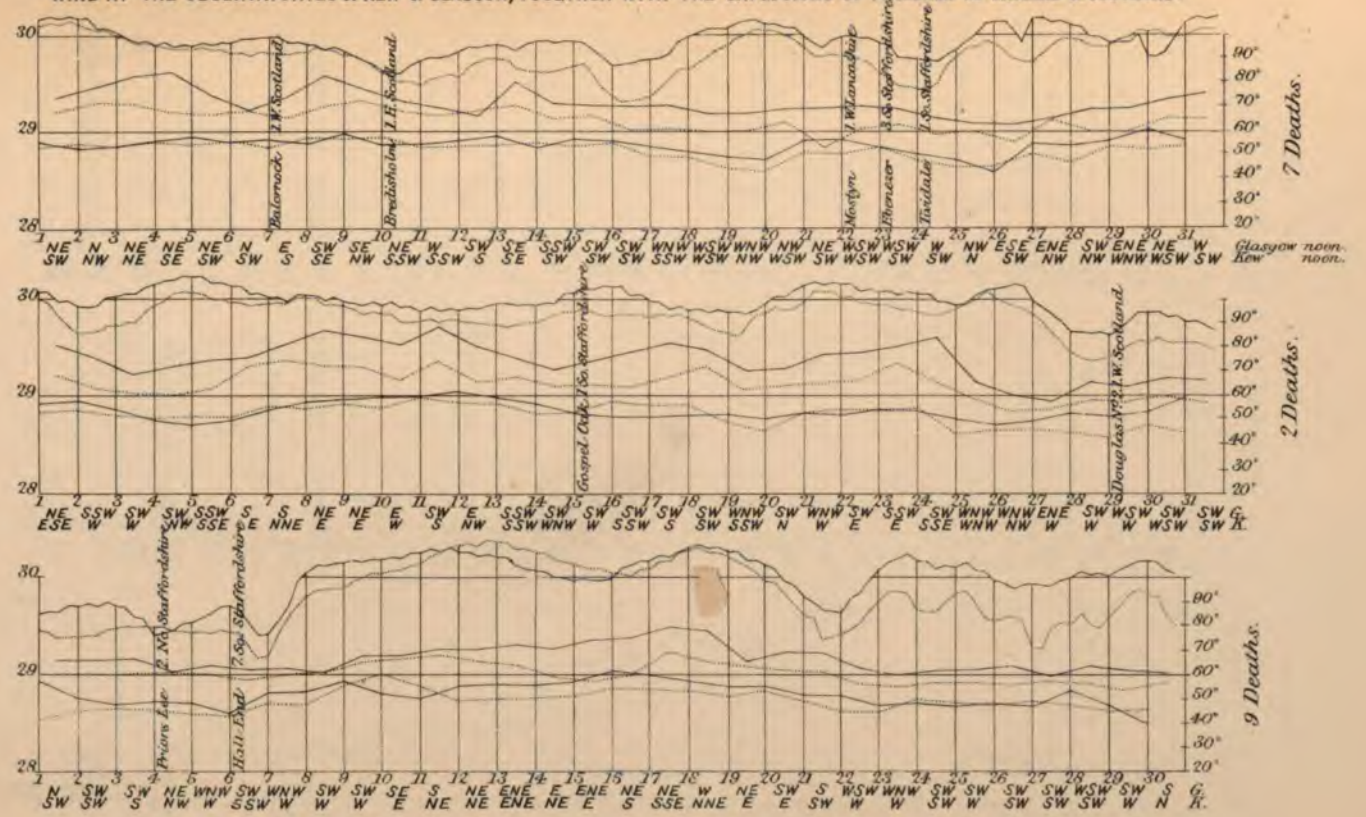
Proceedings No EI of Mc.M.E. 1884-85.

316 4 2

Imperial Inst. Secretariat

DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW, TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1884.



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Kew lines are firm, Glasgow - dotted.
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Proceedings No. E.I. of M. & M.E. 1884-85.

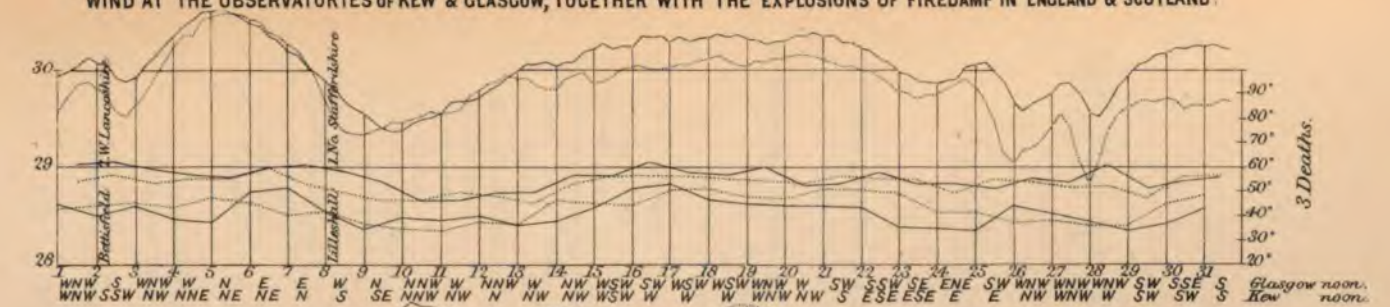
Andrew Reid, Newcastle.

316 c 3

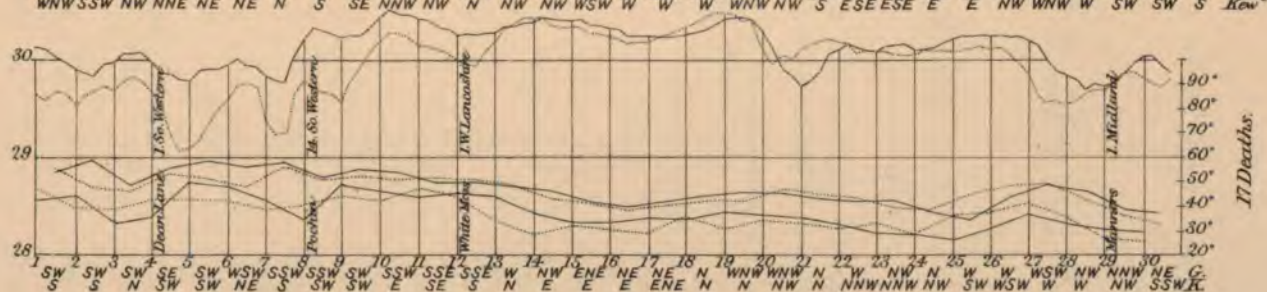
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW, TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1884.

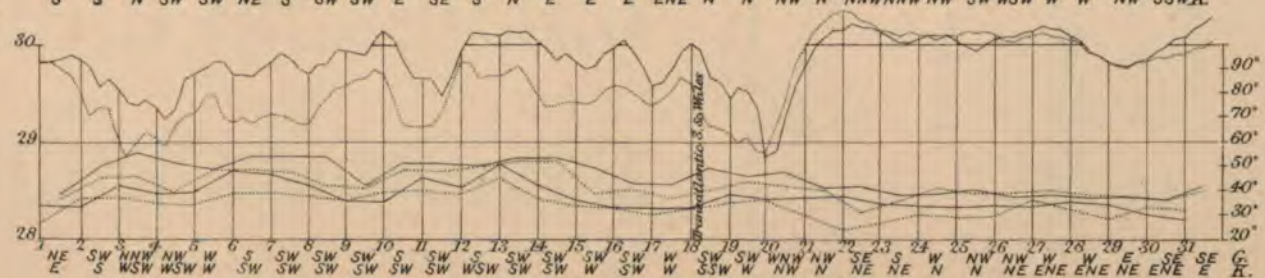
OCTOBER.


30
29
28
90°
80°
70°
60°
50°
40°
30°
20°
3 Deaths.
1 W. Lancashire
Batterfield
Tillotsfield
1 No. Staffordshire
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
WNW S WNW W N E E W N NNW W NNW W NW WSW SW WSW WSW WNW W SW SSW SE ENE SW WNW WNW WNW SW SSE S Glasgow noon.
WNW SSW NW NNE NE NE N S SE NNW NW N NW NW WSW W W W WNW NW S ESE ESE E E NW WNW W SW SW S Kew noon.

NOVEMBER.


30
29
28
90°
80°
70°
60°
50°
40°
30°
20°
17 Deaths.
1 So. Wales
Dearlands
Mr. So. Wales
Pontlottyn
1 W. Lancashire
White Moss
1 Midland
Mapperley
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
SW SW SW SE SW SW WSW SSW SSW SW SSW SSE SSE SSE W NW ENE NE NE N WNW WNW N W NW N W W WSW NW NNW NE G.
S S N SW SW NE S SW SW E SE S N E E E ENE N N NW N NNW NNW NW SW WSW W W NW SSW K.

DECEMBER.


30
29
28
90°
80°
70°
60°
50°
40°
30°
20°
3 Deaths.
Spennithorne & S. Wales
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NE SW WNW NW W S SW SW SW SW S SW SW SW SW SW SW W SW W SSW W NW N NE NE N N NE ENE ENE NE ENE E SE SE G.
E S WSW WSW W SW SW SW SW SW SW WSW SW SW W SW W SSW W NW N NE NE N N NE ENE ENE NE ENE E SE SE K.

The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
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The figures attached to the districts shew the No. of deaths caused by the explosions.

Proceedings No. E.I. of M. & M.E. 1884-85.

Andrew Reid, Newcastle.

316 e

NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

ABSTRACTS OF FOREIGN PAPERS.

MINING PRODUCE OF THE DISTRICT OF DORTMUND (HANOVER, WESTPHALIA, AND RHENISH PRUSSIA) IN 1883.

Produktions-Übersicht der im Oberbergamtsbezirk Dortmund im Jahre 1883, *in Betrieb gewesenen Bergwerke und Salinen.*

A.—Coal Mines.

District.	No. of Collieries.	Produce in Tons.	Persons Employed.
1.—Osnabruck	9 ...	110,630 ...	857
2.—Hamm	4 ...	495,194 ...	1,917
3.—Dortmund, East	14 ...	1,784,709 ...	7,547
4.— Do. West	16 ...	1,948,130 ...	7,873
5.—Witten	9 ...	1,621,977 ...	5,844
6.—Sprockhövel	32 ...	488,878 ...	2,155
7.—Dahlhausen	16 ...	1,912,920 ...	7,464
8.—Bochum	11 ...	2,853,103 ...	9,868
9.—Herne	7 ...	2,118,792 ...	6,961
10.—Recklinghausen	10 ...	1,651,589 ...	5,369
11.—Gelsenkirchen	8 ...	2,818,942 ...	8,919
12.—Essen	8 ...	2,961,379 ...	8,924
13.—Frohnhausen	11 ...	2,722,951 ...	8,553
14.—Oberhausen	14 ...	2,837,801 ...	9,772
15.—Altendorf	19 ...	1,049,754 ...	3,783
16.—Werden	11 ...	287,169 ...	982
Private mines in 1883 ...	199 ...	27,663,918 ...	96,788
Government mines in 1883	2 ...	199,107 ...	1,134
Grand total of 1883 ...	201 ...	27,863,025 ...	97,922
Do. 1882		25,873,332 ...	89,718

B.—Iron-ore Mines.

District.	No. of Mines.	Produce in Tons.	Persons Employed.
1.—Osnabruck	9	202,692	838
2.—Hamm	1	5,800	29
3.—Dortmund, East	2	58,107	187
5.—Witten	1	—	34
6.—Sprockhövel	2	42,880	196
7.—Dahlhausen	1	150,688	517
15.—Altendorf	3	10,163	74
16.—Werden	2	5,770	50
Total of 1883	21	476,100	1,925
Do. 1882		450,946	1,786

C.—Zinc-ore Mines.

District.	No. of Mines.	Produce in Tons.	Persons Employed.
2.—Hamm	1	290	22
5.—Witten	2	22,068	629
6.—Sprockhövel	2	2,756	39
16.—Werden	3	6,473	418
Total of 1883	8	31,587	1,108
Do. 1882		27,561	1,022

D.—Lead-ore Mines.

District.	No. of Mines.	Produce in Tons.	Persons Employed.
1.—Osnabruck	1	5	15
2.—Hamm	1	2	—
5.—Witten	2	308	26
16.—Werden	3	1,296	292
Total of 1883	7	1,611	333
Do. 1882		2,129	343

E.—Copperas Mines.

District.	No. of Mines.	Produce in Tons.	Persons Employed.
6.—Sprockhövel	1	24,490	132
16.—Werden	2	3,721	42
Total in 1883	3	28,211	174
Do. 1882		38,696	209

F.—Salt Works.

District.	No. of Works.	Produce in Tons.	Persons Employed.
1.—Osnabruck	2 ...	1,332 ...	30
2.—Hamm	3 ...	14,257 ...	150
Private works in 1883 ...	5 ...	15,589 ...	180
Government works in 1883	1 ...	2,570 ...	45
Grand total in 1883 ...	6 ...	18,159 ...	225
Do. 1882		15,799 ...	212

N. N. N.

AUXILIARY VENTILATION FOR GASSY PITS.

Zur Ventilation schlagwetterführender Steinkohlengruben. C. Von Steindel. *Zeitschrift des Vereines Deutscher Ingenieure,* 1884, *pp.* 49–53. *One Plate.*

In the Saxony coal-field the seams are thick, lie at a considerable depth, and are generally much inclined. The boundaries of the royalties correspond with those of the farms aboveground, which are often of peculiar shape, and the coal is much cut up by troubles. Gas is met with in large quantities, and ventilation is difficult.

As manager of the Zwickan Colliery, Herr Von Steindel introduced a system of auxiliary ventilation by means of compressed air. Air compressed to 44 lbs. per square inch will stream through a nozzle of from $\frac{1}{16}$ inch to $\frac{3}{16}$ inch diameter, at the rate of from 7·6 cubic feet to 44 cubic feet per minute, and if it be passed through a Körting's blower, and thence through a pipe 33 feet long by 6 inches in diameter, the useful effect, as regards current produced, will be increased about 18 times.

It was found by experiment that when the compressed air was passed straight into the pipe, without the Körting apparatus, the amount carried through was higher still, the effect being 28½ times that obtained in the first case. A plate, showing the general system of ventilation at Zwickan accompanies the article.

The main current of air is carried through the mine in the usual manner, and in addition to this, compressed air is distributed in main pipes from two of the three shafts, and small branches fitted with the simple apparatus described above are led from these into each working place or corner, where a through current cannot be conveniently obtained. The 6-inch pipes may be of zinc or wood, with rough joints, and may be forked and their currents of air subdivided, so as to supply several different boards. The air is compressed by two engines, each of which, making 40 strokes per minute, can compress 1,105 cubic feet of air up to 44 lbs. per square inch, and each has an air vessel with a capacity of 1,006 cubic feet.

The main pipes are of cast iron 4⅞ inches in diameter at the shaft, reduced to 3½ inches in the main passages and to 2 inches and 1½ inches at the face. In ordinary working about one-third of the air is used that the machines can compress, and the amount of air brought into circulation by means of the installation is more than twenty times that compressed.

A. R. L.

COST OF COPPER-LIXIVIATION IN BALÁN.

Kostenverhältnisse bei der Baláner Kupfer-Auslaugarbeit. RUDOLF FLECHNER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 463–465.

Copper is extracted from two different ores at Balán. To one kind, which contains from 5·5 to 5·8 per cent. of copper, the ordinary smelting process is applied; and to the other, containing from 1·3 to 1·7 per cent., that of lixiviation.

In the first case the cost per 100 tons of ore is as follows:—

	£ s. d.	£ s. d.
Coarse metal, labour	4 0 6	
Do. material	15 17 0	
		19 17 6
Roasting process, labour	17 7	
Do. material	1 17 6	
		2 15 1
Conversion of coarse metal into black copper, labour	1 12 6	
Do. do. material	5 14 5	
		7 6 11
		29 19 6
Cost of winning and transporting the ore		8 15 3
Total		£38 14 9
The average percentage of copper in the ore being 5·82, the total cost per cwt. of pure copper comes to		7 6
Cost of refining		6
Total cost per cwt.		8 0

In the second case the cost is:—

	£ s. d.
Labour, including roasting, crushing, grinding, and washing ...	3 2 10
Fuel (wood and coal)	2 10 8
Iron added in the process	19 0
	6 12 6
Cost of winning and transporting the ore	2 3 0
Total	£8 15 6
The average percentage of copper in the ore being 1·5, the total cost per cwt. of pure copper comes to	8 4
Cost of refining	6
Total cost per cwt.	8 10

The smelting process is found to pay for ores containing as small a percentage as from 3·8 to 4, and the lixiviating process, with a percentage of ·8, the latter being only applicable under certain conditions to ores containing combinations of sulphur.

A. R. L.

THE "PETER AND PAUL" BROWN COAL MINE NEAR DUX.

Abbaumethode mittelst Tagebaues bei der Peter- und Paul- Braunkohlen Zeche nächst Dux. ANTON ARLT. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 406–407. *One Plate.*

In the above mine the seam is from 33 to 60 feet thick, at from 13 to 30 feet below the surface, and is worked to the day, the overlying stratum being first excavated. The upper part of the seam, for a thickness of from 23 to 46 feet, is of excellent quality, and is worked off first; the lower part, which is poorer, being taken up afterwards. The method of working is to honeycomb the bottom of the upper thickness of coal with board and pillar workings over an area of from 350 to 600 square yards at a time, the pillars being left just strong enough to support the mass above.

Charges of dynamite are then put into all the pillars and fired simultaneously, which causes the whole mass to fall.

In this way large masses of coal can be quickly and cheaply won, and if the demand be brisk and the coals can be sent away at once, there will be a proportion of

Round coals	...	...	...	...	=	40	per cent.
Medium „	...	...	...	...	=	30	„
Nuts	...	...	...	...	=	10	„
Small coal	...	...	...	...	=	20	„

If the coals have to lie for a considerable time in heap, the percentage of small may rise to 35.

The small coal being unsaleable, is heaped up at the mine and burnt.

The bottom coal is intersected by several bands, and is taken up in successive layers after the top coal has been cleared away well in advance. A. R. L.

ELECTRIC MACHINERY IN MINES.

Die Zukunft der elektrischen Kraftübertragung beim Bergbau. PROF. W. SCHULZ. *Zeitschrift des Vereines Deutscher Ingenieure*, 1884, *pp.* 149–155 *and* 175–179.

Professor Schulz draws an exhaustive comparison between the cost and applicability of electric machinery on the one hand and that of machinery driven by steam, compressed air, or hydraulic power on the other, for boring and cutting machines and underground hauling, pumping, and ventilating machinery.

In the case of boring and cutting machines the transmission of power to the face by electricity is about equal in cost to that by compressed air, and may in some cases be rather cheaper; but, where a plentiful supply and sufficient head of water are obtainable, hydraulic transmission is cheaper than either.

For distances of from 500 to 600 yards the useful effect of the electric transmission is about 50 per cent. against about 20 per cent. for that by compressed air, and to do the same amount of work the respective motive powers required are as 2 to 5. The electric system is proportionally the cheaper, the greater the cost of fuel and the greater the distance to which the power must be transmitted.

Among underground locomotives the steam engine is the cheapest wherever it can be applied. The electric engine gives better results than those driven by compressed air, but the "fireless locomotive," invented by Moritz Honigman, though not yet fairly tried, promises to give better results than either.

In the following table of results for different underground engines an addition should be made for cost of extra ventilation to the results in the first two columns. In these two cases two locomotives were at work.

UNDERGROUND HAULAGE BY LOCOMOTIVES.

	Steam Engines.			Compressed Air Engines.		Electric Engines.
	With Fire.		Without Fire.			
	Doman Mine.	Cessous Mine.	Honigman System.	Petau System.	Mekarski System.	Zaukeroda Coal-mine.
Cost of plant, in £	1,600	1,600	550	650	1,000	800
Interest and depreciation per mile ton, in pence	·42	·14	·50	·79	·81	·44
Cost of haulage per do., in pence	·60	·51	·82	1·18	1·35	1·10
Total cost per do., in pence ...	1·02	·65	1·32	1·97	2·16	1·54
Daily performance, in mile tons	303	882	88	66	99	146
Length of run, in yards ...	2,530	5,030	676	676	676	676
Time per run, in minutes ...	2·3	3·3	1·5	1·5	1·5	2·6
Weight of the machine, in cwts.	86·3	156·3	47·2	53·1	45·2	31·4
	Ft. In	Ft. In.			Ft. In.	Ft. In.
Height of do.	6 3½	6 10½	(?)	(?)	5 1	4 11
Breadth of do.	4 3	5 3	(?)	(?)	3 7¼	2 7½

When several electric locomotives are at work on the same line, the efficiency of the installation is considerably increased.

The electric principle shows to greatest advantage when applied to underground hauling. The following are examples of different systems :—

	Rope and Tail Rope.	Rope and Counter Rope.	Endless Ropes.			Endless Chain.		For Comparison.
			With Great Speed.	With Small Speed.				
	St. Marie Pit, near Aniche.	Von der Heydt Pit, Saarbrücken.	(1) Shire Oaks Pit, in Nottinghamshire.	(2) Bridge Pit, in Nugent.	(3) Meadow Pit, near Wigan.	Burbach Drift, Saarbrücken.	Hasard Pit, Belgium.	Electric Haulage at Zaukeroda Pit.
Cost of plant, in £ ...	1,600	2,300	750	2,300	750	4,000	5,600	800
Interest and depreciation per mile ton, in pence ...	1·36	·255	·29	·37	·39	·78	·22	·445
Cost of haulage per do., in pence	·52	1·01	1·80	3·65	2·00	·73	·22	1·09
Total cost per do., in pence	1·88	1·26	2·08	4·02	2·39	1·52	·44	1·54
Work done per shift, in mile tons	96	720	203	500	148	436	1,983	146
Hauling distance, in yards	600	4,120	920	2,170	640	1,920	3,500	676
Time per run, in minutes...	5·0	3·3	3·3	·6	·5	1·87	1·5	2·6
Duration of shift, in hours	10	10	12	12	12	10	8	16

(1) The full tubs are drawn up an incline of 1 in 48.
(2 Do. do. do. 1 in 62.
(3 Do. do. do. 1 in 21.

From the foregoing table it appears that the electric system will compare favourably with most of the others as regards cost. The "rope and counter rope" haulage system and those by "endless chains" are better adapted for moving very heavy weights.

For "subsidiary hauling engines" a comparison of cost between electricity and compressed air shows considerably in favour of the former; but hydraulic power, in cases where it can be applied, is cheaper still, unless the water has to be carried for very long distances. A. R. L.

CORRUGATED BOILER FLUES.

Wellrohr-Dampfkessel. Prof. R. R. Werner. *Zeitschrift des Vereines Deutscher Ingenieure,* 1884, *pp.* 135–139. *Illustrated in the text.*

The professor compares the Cornish boiler with single furnace with the Lancashire boiler with double furnace, and after showing that the principal disadvantage of the former lies in the weight of plates and stiffeners required to keep its large furnace from collapsing, proceeds to investigate the relative properties of plain and corrugated tubes. In an example given it is shown by calculation that to resist outside pressure a plain tube would have to be 2·6 times as heavy as a corrugated one of the same diameter. For the same strength the tubes could thus be much thinner if corrugated; but they must not be less than three-eighths of an inch, or they cannot be welded.

The strength of the welds has been found by experiment to be about ·88 per cent. of that of the corrugated plates.

The strength of a corrugated tube in the direction of its length is stated to be about the same as that of a plain tube of the same size and thickness.

As regards heating surface, that of a corrugated tube is calculated to be about 1·12 times that of a plain tube of the same mean diameter. A. R. L.

THE PULSOMETER.

Zur Verwendung des Pulsometers. Wilh. Rodler. *Zeitschrift des Vereines Deutscher Ingenieure,* 1884, *pp.* 139–141. *Illustrated in the text.*

In the railway station at Lemberg, a pulsometer, No. 4, was used to supply the place of two steam pumps of from 3 to 4 horse-power, which were undergoing repair, and it was found that the work done per cwt. of coal burnt was about 20 per cent. greater than it had been previously.

A trial was made of the same pulsometer at the water station of Krasne, and, though its performance was not quite so good as before, the work done was considerably more in proportion than that done by the steam pump.

Further trials with different pulsometers showed that these good results were not always maintained. In one case two of the same size and make gave widely different results, and in another a pulsometer, after working well for about a year, became less efficient, the pulsations per minute falling from 56 to 42, and attempts to put it right were unavailing.

It seems that the causes of such failures are not yet quite understood, and the chances of the pulsometer coming into general use will depend very much on whether it be found practicable easily and quickly to remedy such defects. A. R. L.

FORM AND ARRANGEMENT OF PIT SHAFTS.

Form und Einteilung der saigeren Schächte. F. BAUMANN. *Zeitschrift des Vereines Deutscher Ingenieure,* 1884, *pp.* 296–298. *One Plate.*

Herr Baumann gives descriptions and sectional plans of 22 different shafts of various forms, from circular to rectangular, and with or without passage-ways and separate divisions for pumps and ventilation.

In order to economize space, most of the earlier German shafts were made rectangular, but it was found that round shafts were easier and cheaper to sink, and more suitable to the application of metal tubbing, and that the waste of space and other disadvantages due to the circular form were less considerable than had been supposed.

Herr Baumann advocates the abolition, as far as possible, of partitions in the shaft between the cages, and the employment, as guides for the latter, of double T-irons on one side only.

Taking an average sized tub as 4 feet 11 inches long by 2 feet 5½ inches broad by 3 feet 3½ inches high to carry from 9¾ cwts. to 10¾ cwts., a single-tub cage will require a section of 5 feet 11 inches by 3 feet 3½ inches, and one for two tubs will be 6 feet 7 inches by 5 feet 11 inches, or 11 feet 6 inches by 3 feet 3½ inches, according as the tubs are placed side by side or one behind the other. The double T-iron guides take up about four inches more room, which must in each case be added to one of the dimensions given above. A. R. L.

SHAFT AND WINDING MACHINERY AT THE BOCKWA-HOHNDORF-VEREINIGTFELD COLLIERY.

Fördermaschinenanlage auf Schacht No. I. der Steinkohlen-Actien-Gesellschaft Bockwa-Hohndorf-Vereinigtfeld bei Lichtenstein. B. OTTO. *Zeitschrift des Vereines Deutscher Ingenieure,* 1884, *pp.* 213–219, 233–238, 254–259, *and* 278–284. *Four Plates.*

The Bockwa-Hohndorf Pit is said to be the deepest in existence,* its No. 1 shaft being sunk to a depth of 474½ fathoms. The sinking was much hindered by large feeders of water, and its total cost, including charges for walling and tubbing, came to as much as £49,188, or about £104 per fathom.

The buildings at bank are of a substantial character, and cost as follows:—

	£
Shaft-head house	674
Engine house	561
Boiler house	310
Chimney	472
Air doors	9
Barrack for men	225
House for air-compressing machinery	171
Total	£2,422

The shaft is a rectangular one, about 21 feet by 6 feet, and has four divisions, of which two are for drawing coals, each 6 feet 6 inches long, and one for the pumps, the fourth division next the pump shaft serving as a passage-way. The cages are two-decked, each carrying four tubs at a time.

The winding-engine is a double one, having a horizontal cylinder, working a crank at each end of the main driving shaft. The cylinders are each 38 inches in diameter

* There are several mines deeper than this:—The Adalbert Shaft, Przibram, 572 fathoms; Viviers Rennis, Gilly, Charleroi, 570; and others.—SUB-EDITOR.

by 5 feet 11 inches stroke, and the speed of working is from 35 to 38 strokes per minute, the pressure of steam being from 45 to 60 lbs. per square inch.

The rope reel has a diameter of 9 feet 2 inches, and the rope winds on to it to a diameter of 20 feet.

The engine has expansion valves on the Krause system, and a self-acting stopping apparatus so arranged as to gradually cut off the steam as the cage comes to bank. It is fitted with two independent brakes, one of which is worked by steam, and has a cylinder of 9⅞ inches diameter by 11¾ inches stroke.

Diagrams taken from the winding-engine after it had been four years at work, gave a mean total of 372 I.H.P., and a useful effect of 236 H.P.

The consumption of coal was calculated to be about 10·3 lbs. per I.H.P. per hour, when the engine worked with expansion, and 16·7 lbs. when it worked with full pressure.

The greatest possible output per day of 18 hours is reckoned at 926 tons, for a depth of 465 fathoms, and 890 tons per day when the depth reaches 492 fathoms, the actual output at present being about 400 tons per day.

The total cost of winding-engine and mountings was £3,754, and the working expenses per year come to £1,362. The weight of the engine, including rope reel, is 102 tons.

To produce steam for the winding, pumping, and subsidiary engines there are eight boilers, of which seven are kept in constant work. Each of these consists of an upper cylindrical tube of 4 feet 9 inches diameter by 35 feet long, connected with a lower tube, or boiler proper, of 4 feet diameter by 3 feet 4 inches long. The working pressure is about 70 lbs. per square inch. The heating surface for each boiler is 586 square feet, and the grate surface 27 square feet, and the area of the chimney one-seventh of the grate surface of the eight boilers, or about 31 square feet.

The feed water is raised from a depth of 109 fathoms by a pump of 7⅞ inches diameter of plunger by 4 feet 3 inches stroke, into a reservoir of 4,236 cubic feet capacity, whence it is pumped into the boilers by a horizontal steam pump of 4⅞ inches diameter of plunger by 8 inches stroke, making from 40 to 45 strokes per minute. In addition to the latter a small steam pump and a Körting's Injector are used as auxiliaries.

The cost of the boilers and feed pumps, exclusive of buildings, was as follows:—

	£
Eight boilers	1,565
Covering composition and fittings ...	392
Stonework seating	987
Two feed-pumps and Körting Injector ...	176
Feed water reservoir	68
Total	£3,188

The winding ropes are flat, $4\frac{5}{16}$ inches by ¾ inch, and are each made up of eight four-stranded cast-steel ropes, the strands in their turn containing six wires each. Each rope thus contains 192 wires of $\frac{5}{64}$ inch diameter and will bear a strain of 75·8 tons, or about 7·3 times that due to its ordinary working load. Each rope is 547 fathoms long, its weight is 6·1 tons, and its cost was about £289.

One of the ropes had to be renewed after sixteen months' work, and another one after fifteen months was still in good order.

The pulley frames and the cross-bearers carrying the pulleys are of iron, and the total weight of the bearers and their foundations is about 27½ tons. The pulleys are 13 feet 9 inches in diameter, and their total weight, including foundations, about 12 tons. Each cage weighs 38 cwts.

The cost of sinking and completing the No. 1 shaft came to £49,188, and, deducting 10 per cent. as the proportion due to the division containing the pumps, the nett cost of the winding shaft proper comes to £44,270.

Deducting part of the cost of boilers and chimney, which are partly used for other purposes, the total cost of plant, etc., due to the winding installation proper is:—

	£
Shaft house and engine house	1,234
Boiler house and chimney (part)	391
Boilers (part)	1,595
Winding engine and gear	3,754
Guides and shaft woodwork	274
Pulley frames...	96
Fittings at bottom of shaft	377
Pulley cross-bearers	653
Pulley wheels	245
Signal apparatus	19
Cages	118
	8,756
Cost of winding shaft (as above)	44,270
Ground rent, accommodation for workmen, fittings at bank, etc.	1,470
Total	£54,496

The working expenses for the year 1881 amounted to £2,766. A. R. L.

NOTES ON THE SIEMENS-MARTIN PROCESS.

Notizen über den Siemens-Martin Stahlprocess bei dem Grazer Südbahn-Walzwerke. JULIUS PROCHASKA. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 475–476.

Herr Prochaska has introduced some alterations into the working of the Siemens-Martin process, and gives results for some furnaces which have been at work for five years. Instead of the usual syphon a regenerator is placed horizontally before the furnace, and the air and gas are passed through separate channels directly on to the steel bath. The crown of the furnace is convex instead of concave. For each charge the carbon in the bath is reduced to from ·12 to ·14 per cent., the re-carbonizing being effected by means of Ferro-manganese. There are four Siemens-Martin furnaces in Graz, two being on the improved system. One of these latter produced 431 charges in eight months and seven days, another 539 charges in nine months and three days. The work was stopped every month for from three to six hours to allow the valves of the generators to be cleaned, but no other stoppages occurred. The capacity of each furnace is 12·3 tons. During the periods named the materials required by each for the production of one ton of ingot steel were:—

	Lbs.
White and grey pig iron	733
Steel and iron scrap	1,610
Ferro-manganese	39·3
Galician smelting coal	970
Heating coal	582

Making allowance for stoppages, the production of one furnace during twenty-four hours came to 23·62 tons of steel. One of these improved furnaces, capable of dealing with a charge of 14·76 tons, was started in 1883 in the works of the John Cockerill Company, Seraing.

The two other furnaces, fitted with the above improvements, but with vertical regenerators, worked during six and nine months respectively without needing repairs, producing 14·7 tons of steel in twenty-four hours. For each 100 lbs. of steel they required about 68 lbs. of smelting and 20 lbs. of heating coal, a much larger quantity than that required for the two on Herr Prochaska's system.

Some improvements in the casting process are also communicated. To do away with the hydrostatic pressure on the steel while flowing, a small extra pan is fixed under the melting pan. From the smaller vessel, which is always kept full, two openings lead each into an ingot mould, into which the steel flows quietly and without pressure, the usual covering not being required. Receipts are given by which a sound steel casting with a smooth fair surface may be obtained. Soundness is obtained by the addition of ·30 to ·40 per cent. of silicium, ·60 to 1·0 per cent. of manganese, and ·40 to ·60 per cent. of carbon. To give the casting a fair surface it is moulded in pure fire-proof quartz sand mixed with 12 per cent. of ordinary bran. The moulds are coated with a solution of fossil meal in glue water, which has been found far superior to graphite. J. N.

IMPROVEMENTS IN COKE-OVENS.

Neuerungen in der Construction von Cokesöfen zur gleichzeitigen Gewinnung von Theer und Ammoniak. Dr. C. Otto and Co. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 510–512. *One Plate.*

The Coppée oven, with vertical flue channels, has been altered by Herren Dr. Otto and Co., in order to obtain the tar and ammonia. The ovens are built with two horizontal gas chambers under them, into the lower of which open the flue channels, admitting the gases from the top of the oven. The latter is provided with piping to convey the gases to and from a distiller, where they are freed from their tar and ammonia. The further details of the construction vary according to the conditions under which the distillation has to be carried on. It may either last as long as the coking itself or only a certain part of that time. In the latter case an even number of ovens are arranged in a block, adjacent pairs always working together. Supposing the time required to coke one charge to be forty-eight hours, and the time during which the gases have to be distilled to be twenty-four hours, then the second oven would be charged twenty-four hours after the first. The latter, during the remaining twenty-four hours of its charge time, receives the distilled gases, and these, combined with its own coking gases, flow into its lower and upper chambers, and from these into the upper gas chamber of the second oven before leaving for the main eduction channel, thus heating this coking chamber, the gases of which during this time are exhausted for the purpose of distillation. At the end of the second twenty-four hours the first oven is re-charged and the communications of the ovens with the distiller and with their own gas chambers are reversed. Thus a constant heating of all parts of the ovens is effected. For a continuous production of tar and ammonia the ovens are provided with pipes inserted in their top vaults, through which the gases are exhausted into the distiller. There are no eduction openings for the gases except these. After having been distilled the gases are carried back, mixed with air, and injected into the gas

chambers below the ovens, whence they rise through the vertical flue channels, thus heating the side walls of the ovens. The tops of these channels communicate with each other and also with those of the other ovens. There may be either one or two bottom chambers in which the gases are burnt, the working varying accordingly. In the case of two chambers the ovens are started with gases produced in a separate generator, the distilled coking gases are injected into and burnt in the upper chamber, into which open one-half of the vertical or horizontal flue channels. The gases rise in these and return through the other channels into the lower chamber, whence they escape into the main channel. Close to the top of the latter are carried the induction pipes for the air and the gases. There may be injectors on both ends of the upper chamber. In the case of one gas chamber only, each alternate oven is provided with the injecting pipes for gas and air. The gases rise in the flue channels, then pass into those of the intermediate oven, which they descend, and leave through the gas chambers of the latter for the eduction channel. The flow of the gases in the side wall channels is regulated by slides. The patentees have constructed one set of coking ovens to the last-mentioned design. The distilled ammonia water is used for the production of sulphate of ammonia. Each 100 tons of coked coal produced tar to the value of 15s. 4d., and sulphate ammonia to that of £1 10s. 7d. J. N.

HEATING BY BLAST FURNACE GASES.

Ueber den Werth und die Verwendung der Hochofengichtgase zur Erzeugung hoher Temperaturen. Prof. Ehrenwerth. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 537–539.

Until lately gases escaping from blast furnaces have been used for those heating purposes only in which a low temperature was sufficient. Although these gases contain less nitrogen than those produced for heating purposes by specially adapted generators, they do not give the same caloric effect, owing to the large proportion of carbonic acid which they contain. This amounts to from ·4 to 1·1, whereas in the generator gases it is generally less than ·3. Prof. Ehrenwerth at first proposed to regenerate the blast furnace gases whereby the acid was to be reduced to oxide, thus producing a gas mixture which, by its combustion, gives a temperature as high as that attained by generator gases. This plan has been adopted in an ironworks in upper Italy, where the blast furnace gases are used for puddling. The gases are regenerated by passing through red-hot coals. This may be done either continuously in one furnace or discontinuously in several, and these furnaces are worked best with hot blast. For the regeneration of 100 lbs. of gas, containing 20·6 lbs of carbonic acid and 24·3 lbs. of carbonic oxide, 17 to 20 lbs. of coke or coal would be required. Although it is impossible to reduce all the acid to oxide, the theoretical temperature of combustion is always raised above that usual with generator gases. The regenerated blast furnace gases may be used to great advantage in the Martin process. Thus, with only an additional expenditure of coal for the regeneration, a part of the pig-iron produced by a furnace can be converted into steel on the spot. If the heating of the charges and the blast were done independently, so that all the gases leaving the blast furnaces could be regenerated for the Martin process, the latter would be more economical than that of Bessemer. Prof. Ehrenwerth is the author of a treatise on the regeneration of blast furnace gases, which also contains a design for a regenerative furnace to work continuously. J. N.

THE TESTING OF IRON AND STEEL.

Ueber Festigkeitsversuche. Welche Factoren können das Resultat der Zerreissprobe beeinflussen? EDUARD GOEDICKE. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 557–559 *and* 575–579. *Illustrated in the text.*

The results of tests on iron or steel bars are generally put into a formula in which the breaking load is combined with the contraction of area, the elongation being considered as of secondary importance. It has recently been established by numerous tests that, owing to want of uniformity, the elongation may at times be very small with a large contraction, and also that the more a test piece has been worked the smaller will be the elongation, notwithstanding that the breaking load and the contraction remain the same. For this reason the elongation is to be considered as affording the best testimony to the soundness and ductibility of the material tested. The percentage of elongation is nearly constant in bars of similar section and the same material, but it varies with the area of the section. This shows the necessity of specifying the areas of test bars in addition to their elongation in order to arrive at a fair comparison. The percentage of elongation varies further with the length of the test bar, and also with its proportion of breadth to thickness; thus the largest elongation has been obtained with bars, the breadth of which was six times the thickness. The results of the tests vary with their duration; the shorter the time taken to break the bar, the higher being, as a rule, the breaking load and the contraction and the smaller the elongation; soft materials being more influenced by this than hard ones. Faults in the dressing of the test pieces affect the result the less the greater the area of the section. If the axis of the test bar does not correspond with the direction in which it is being torn asunder, the breaking load and the elongation will be decreased. J. N.

COPPER IN LUXEMBURG.

Analyse du Minerai de Cuivre de Stolzembourg (Grand-Duché de Luxembourg). BY ARNOLD GODIN. *Revue Universelle des Mines, Sér.* 2, *Vol. XVI., p.* 242.

Describes a vein of rich copper-pyrites now worked at Stolzemburg, on the northern flank of the Goldberg. The lode crops out on both sides of the river Klaang. It is of considerable width, with a gangue of nacreous calcite arranged in longitudinal ribs, and chalkopyrite in nests along the hanging wall. The analysis given shows the unusual amount of 28·5 per cent. of copper. The country consists (as in Cornwall, it may be noted,) of compact clay slate of Middle Devonian (Coblentzian) age.

G. A. L.

ALGERIAN IRON ORES.

Sur les Terrains de Gneiss des environs de Bône (Algérie). BY A. PARRAN. *Bulletin de la Société Géologique de France, Sér.* 3, *Vol. XI., pp.* 503–511. *Two figures in the text.*

Some iron ores are briefly described in this paper which occur interbedded among the great series of gneissic rocks which occupy the greater part of the country around Bône. The ore consists of magnetite and hæmatite, and is irregularly manganesiferous. It is found in lenticular masses at the base of limestone beds which, with micaceous and garnetiferous schists form, in this region, a series underlying the upper foliated gneiss and overlying the older gneiss of the higher ground. The ore deposits are situated near the sea. Few details and no analyses are given. G. A. L.

INVERSION OF STRATA.

Superposition anormale du Trias sur le Lias dans les Cévennes. By G. Fabre. *Bulletin de la Société Géologique de France, Sér.* 3, *Vol. XI., pp.* 93–94.

In 1876 a boring was put down at Saint Jean-de-Buèges, at the foot of the Jurassic crags of the Sérane, in Hérault. The object was to seek for coal. The bore started in Triassic rocks, dipping south about 30°. The first 49 metres (160·9 feet) continued in Trias, but from that depth to 138 metres (452 feet), when boring was stopped, the beds were the grey micaceous marls which in this region characterize the Upper Lias. This the author regards as a distinct case of inversion of the beds, due to proximity to the great Cévennes fault.

M. Parran, who executed the boring, however, thinks the evidence insufficient to prove that the beds met with beneath the Trias were really Lias. G. A. L.

STYRIAN LIGNITES.

Note sur la Constitution Géologique des bassins de lignite des environs de Cilli (Basse-Styrie). By — Smeysters. *Revue Industrielle des Mines, Sér.* 2, *Vol. XVI., pp.* 33–37. *Plates IV.–VI.*

Cilli is a bathing-station in Lower Styria, and the lignite occurs chiefly at Buchberg, Liboje, and Tüffer, respectively 5, 5, and 8 kilometres (3 and 5 miles) from that place. The lignite is perfectly mineralized, belonging to the "Glanzkohle" variety. It very much resembles true coal, but is lighter, of a duller lustre, and has a semi-conchoidal fracture. It occurs in deposits of Lower Miocene age, known by the Austrian geologists as the Sotzka beds. The Buchberg basin contains four seams, of which the chief varies from 5 to 12 metres in thickness (16 to 39 feet). The faults and fissures in the rocks are here filled with a fine white clay, used in the manufacture of the ware for which Cilli is noted. The Tüffer basin is much larger than the last—190 by 40 kilometres on the average (114 by 24 miles). The mines are, in this coal-field, all on the right bank of the Sann, although the lignite is known to occur on the other side. Details of thickness, etc., as to this and the third basin are not given. A map and sections show the lie of the beds very clearly, though without pretence to accuracy of detail.

G. A. L.

SALT AT SALIES (BASSES-PYRÉNÉES).

Sondage de Salies. By Marcel Bertrand and — Chavanne. *Bulletin de la Société Géologique de France, Sér.* 3, *Vol. XII., pp.* 33–34. *One figure in text.*

Salt springs have long been known at Salies, near Orthez, in the Department of the Basses-Pyrénées, but this boring is specially interesting on account of its position at the southern extremity of a mass of Serpentinous rock, in a little valley where no great thickness of alluvial deposits could be foreseen. The spot selected for the hole was close to the lower boundary of the outcrop of Cretaceous rocks. The result is to prove the unexpected occurrence at this point of a narrow and long band of Trias, surrounded, in an unexplained manner, by Cretaceous beds. The upper part of the bore was through 49 metres (161 feet) of alluvium and drift, then came 161 metres (528 feet) of Triassic beds lying nearly flat, and at 210 metres from the surface (689 feet nearly) good rock salt was struck. G. A. L.

MINERAL RESOURCES OF THE ANDAMAN ISLANDS.

1) *On Native Lead from Maulmain [Burma], and Chromite from the Andaman Islands.* By F. R. Mallet. *Records of the Geological Survey of India, Vol. XVI., pp.* 203–204.

(2) *On some of the Mineral Resources of the Andaman Islands in the neighbourhood of Port Blair.* By F. R. Mallet. *Ibid, Vol. XVII., pp.* 79–86.

The country about Port Blair, consisting chiefly of sandstone and shale much altered in places by eruptive rocks, is the only portion of the Andaman Islands of which the geology is known. Nests of lignite occur here and there in the sandstone. Veins of hæmatite, associated with iron and copper pyrites, are common near the coast at Ráng-u-Chàng. With regard to these pyritous lodes the author says:—"At present there is no demand for pyrites in India, but were such to spring up, ore like that hitherto obtained in the Andamans could not possibly contend against that from Spain." (pp. 82.) Magnetic iron-sand is found at Havelock Island. Chromite, supposed to be derived from the Serpentinous rocks of the islands, has been found in some abundance at Chakargaon in large blocks, and at Rutland Island as crystalline sand. Platinum was carefully sought for but not found. Limestone (a good marble), Serpentine, and Jasper are the only useful rocks mentioned. G. A. L.

MINERAL RESOURCES OF TINNEVELLY (MADRAS).

On the Geology of the Madura and Tinnevelly Districts. By R. Bruce Foote. *Memoirs of the Geological Survey of India, Vol. XX., Part* 1, *pp.* 1–103. *With large folding Map.*

This region yields but few useful minerals. Iron is the only metal. The ore is an earthy hæmatite, very abundant in the lateritic deposits in the north of the Vaigai. It was formerly largely smelted at Ayangudi, in the southern part of Pudu Kottai State. The present absence of wood in the region now prevents smelting, but in the beginning of the century there were extensive jungles. The only other economic minerals mentioned are building stones—the harder forms of laterite, various kinds of gneissic rocks, gritty sandstones, and fine crystalline limestone being all used. Tufa, including the nodular form or kankar, are the chief sources of lime.

G. A. L.

THE RAIGARH-HINGIR COAL-FIELD (INDIA).

On the Selection of Sites for Borings in the Raigarh-Hingir Coal-field. By Will. King. *Records of the Geological Survey of India, Vol. XVII., pp.* 123–130. *With Map.*

This region is situated about 22 miles N.N.W. of Sambalpur, partly in the Raigarh and partly in the Hingir country. The exploration now reported on was made on behalf of a new section of the Bengal and Nagpur Railway. The coal occurs in the Barakar series, here easily dintinguished by the "tesselated ironstone" rock, which is one of its most persistent members. The coal-bearing beds are succeeded by a great series of sandstones, probably of Gondwana age, and overlie gneissic rocks. Several outcrops of good workable seams have long been known, 6 and 4 feet in thickness at the surface, and the author has selected those spots at which it will be advisable to bore in order to prove the extent of the seams, and has divided the coal-field into six sections suitable for future colliery workings. All these points are clearly shown on the map. G. A. L.

THE ORIGIN OF COAL.

(1) *Sur la formation de la houille d'après un mémoire de M. Grand 'Eury.* By the Marquis de Saporta. *Bulletin de la Société Géologique de France, Sér.* 3, *Vol. XI., pp.* 77–89.

Gives a clear summary of M. Grand 'Eury's views (see "Transactions of the North of England Institute of Mining and Mechanical Engineers," Vol. XXXIII., Abstracts, p. 19,) as to the formation of coal, which the author fully adopts.

(2) *Observations sur la théorie de M Grand 'Eury.* By — Virlet d'Aoust. *Ibid, pp.* 89–91.

The writer disagrees with M. Grand 'Eury, and also with the somewhat similar views of M. Fayol, which he states are based merely on the accidental state of things observable at Commentry and in a few other coal-fields only. He calls attention to a theory on the origin of coal broached by him in 1849, when he showed that most of Coal-Measure rocks are of littoral origin, and that the alternations of coal-seams with other deposits are the result of slow successive upheavals and sinkings of the earth's crust, to which he had given the name of secular oscillations.

Same subject. By — Douvillé. *Ibid, p.* 92.

States that though possibly true for the coal-basins of Central France, M. Grand 'Eury's theory is not applicable to localities where, as in Belgium, seams are continuous and uniform in character over very large areas.

Note.—It will be remembered that M. Grand 'Eury regards coal-seams as having been formed chiefly by water-deposition of drifted plants, and only partially, if at all, by vegetation *in situ*. G. A. L.

THE LANGRIN COAL-FIELD (INDIA).

Report on the Langrin Coal-field, South-west Khasia Hills. By Tom. D. La Touche. *Records of the Geological Survey of India, Vol. XVII., pp.* 143-146. *With Map.*

The coal of this region is of Cretaceous age. Several seams have been observed cropping out at the surface 3 and 4 feet in thickness, whilst one more than 6 feet thick is recorded from the north bank of the Um Plu by Col. Godwin-Austen. The analyses show the following percentages:—Moisture, 5·84 to 3·02; volatile matter, 35·16 to 39·58; fixed carbon, 50·40 to 50·80; ash, 8·60 to 6·60. G. A. L.

THE UMARIA COAL-FIELD (INDIA).

Additional notes on the Umaria Coal-field, South Rewah Gondwana Basin. By Theodore W. H. Hughes. *Records of the Geological Survey of India, Vol. XVII., pp.* 146-150. [See "Transactions of the North of England Institute of Mining and Mechanical Engineers," Vol. XXXIII., Abstracts, p. 31.]

"The facts now established in regard to the Umaria coal-field are: 1.—That there is an abundant store of coal. 2.—That there is a convenient working thickness of at least 7 feet of coal. 3.—That the coal lies within easy access of the surface. 4.—That the dip is slight. 5.—That the working power of the coal is almost equal to that of the Karharbari coal. 6.—That there is a good roof to the coal. 7.—That the coal-measures are not heavily watered" (p. 150). G. A. L.

MINERAL RESOURCES OF AFGHAN FRONTIER.

Geological Notes on the Hills in the neighbourhood of the Sind and Punjab Frontier between Quetta and Dera Ghazi Khan. By W. T. Blanford. *Memoirs of the Geological Survey of India, Vol. XX., Part* 2, *pp.* 1–136. *Three Plates and large folding Map.*

In the district described there is a deficiency of useful minerals, but the following are noted in the chapter on Economic Geology (page 125). Coal of Eocene age occurs at Mach, in the Bolán Pass, and at Sháhrág, on the Harnai route from Quetta to Sibi. The quality is good, but the seams are too thin and inconstant to be profitably worked on a large scale. Similar coal is known in the Luni Pathan country at Chamorlang, west of the Sulemán range. Petroleum is said to occur in the Mari hills, four or five days' march east of Gandkhindaf, on the Harnai road to Quetta, but the locality was not visited by the author. The amount of oil is probably small. Sulphur is met with at several localities. It is chiefly mined near Bágh, but Mr. Blanford thinks it probable that it is rather widely distributed in the Eocene deposits of the region. Gypsum is found in veins, irregular masses, and beds at several points in the Tertiary rocks, sometimes, as in the Sangarh Pass, west of Maugrotha, associated with sulphur. The Cretaceous and Eocene limestones are the chief building material of the country.

G. A. L.

RÁIPUR LIGNITE (INDIA).

Note on Lignite near Ráipur, Central Provinces. By Pramatha Nath Bose. *Records of the Geological Survey of India, Vol. XVII., pp.* 130–131.

This lignite was found in the beds of the Karun river (also known as the Kumeri or Karoon), 3 miles S.W. of Ráipur. It is a bed of carbonized logs, and of good quality (28·30 to 30 per cent. of fixed carbon, 44·84 to 52·36 of volatile matter, no sulphur, and 5·10 to 6 of ash). Should the thickness and extent of the seam prove favourable, it would be of commercial importance in this district, where there is no coal and wood is extremely dear.

G. A. L.

COAL MEASURE INSECTS.

Sur un nouvel insecte fossile des terrains carbonifères de Commentry (Allier), et sur la faune entomologique du terrain houiller. By Charles Brongniart. *Bulletin de la Société Géologique de France, Sér.* 3, *Vol. XI., pp.* 142–151. *Plate IV.*

In this paper a complete list of all the Carboniferous insects described up to the present time is given. These comprise 18 *Neuroptera*, 72 *Orthoptera*, of which 62 belong to the *Blattidæ*, 3 *Hemiptera*, 1 very doubtful *Lepidopteron*, 3 *Coleoptera*, which may turn out to be nothing but fossil fruits, and 14 *Palæodictyoptera*. To these 111 described insects must be added 440 undescribed forms quite recently found at Commentry, and which will be studied by the author. Altogether 551 types, of which 362 are *Blattidæ*. As insects of this family are now found inhabiting damp and dark localites their remarkable preponderance in Carboniferous limes may, the author thinks, help to throw considerable light on the climate then prevailing. The new fossil insect figured is a gigantic Orthopteron nearly 10 inches long. It is named *Titanophasma Fayoli*.

G. A. L.

THE CHOI COALS (INDIA).

Report on the Choi Coal Exploration. By G. F. Scott. *Records of the Geological Survey of India, Vol. XVII., pp.* 73–78. *With large folding Map.*

The Choi and Mungi district is ten miles south of Attock, in the Kala Chita range. Borings at seven localities are described, with the result that little or no coal of any value has been found. The area is one of contorted rocks, chiefly of Eocene age, and carbonaceous black shales, or impure coals, which seem to be good gas producers, but lie in pockets, and are otherwise worthless, occur near their base. G. A. L.

Notes on a Traverse through the Eastern Khasia, Jaintia, and North Cachar Hills. By Tom. D. La Touche. *Records of the Geological Survey of India, Vol. XVI., pp.* 198–203.

The object of the exploration was to search for coal and iron within reach of the proposed railway from Silchar to the Brahmaputra Valley through the North Cachar Hills. The results were unfavourable; but coal, 3 feet thick in one or two seams, was found in Cretaceous sandstone rocks at Jarain, and some had been worked at Lakadong, where 500 maunds were extracted in 1882. A small seam was also seen at Satunga. Iron was formerly obtained by the natives from "a highly ferruginous drift which is found in most of the hill streams." "The other iron ore deposits are very scattered, and would probably not repay systematic working" (page 203). G. A. L.

CALIFORNIAN GEOLOGY.

Note sur la Géologie de la Californie. By Jules Marcou. *Bulletin de la Société Géologique de France, Sér.* 3, *Vol. XI., pp.* 407–435. *Plate IX.*

A short general account of the geology of the State, comprising the results of a recent visit by the author, and many views contrary to those held by the officers of the Geological Survey of the State. The rocks recognised by him as occurring in the State are the following:—1.—*Syenitic granite*, forming the eastern and central portions of the Sierra Nevada, and forming the original repository of the gold of the region, which occurs in quartz reefs running in the same direction as the Sierra, within the granite, and especially in connection with dioritic and serpentine intrusions. 2.—*Metamorphic* rocks, mostly of uncertain age, but comprising beds of Cambrian date. These occur chiefly in the central and western portions of Mariposa, Tuolumne, Calaveras, Amador, El Dorado, Placer, Nevada, Tuba, Butte, and Plumas counties. 3.—*Carboniferous rocks*, scarcely a thousand feet thick, occupying a very small extent of country in Shasta and Butte counties. These beds are of the Mountain Limestone marine type. 4.—*Trias*, also, according to this writer, occurring over a very limited area in Plumas county 5.—*Infra-Lias* or *Rhætic*, in a narrow band between the rivers Merced and Stanislas. 6.—*Lower Lias* (*Sinemurian*), in patches at Mormon Station, Plumas county. 7.—*Cretaceous rocks* occur at one point only, in the Upper Sacramento, near Horsetown and Weaverville. 8.—*Tertiary* rocks, Eocene, Miocene, and Pliocene, form more than a third of the entire area of California. 9.—*Quaternary* or *Gold-bearing Gravels*, in which all the *placer* workings are located.

American geologists, such as Messrs. Gabb, Whitney, Emmons, etc., regard much of the metamorphic series as of Liassic and Triassic age, and refer the original gold-bearing quartz reefs to that period. What M. Marcou calls Tertiary they regard as Cretaceous, whilst his Quaternary they refer to the Tertiary. G. A. L.

TURQUOISE MINES OF PERSIA.

The Turquoise Mines of Nishâpûr, Khorassan. By General A. Hontum Schindler. *Records of the Geological Survey of India, Vol. XVII., pp.* 132-142.

These are the principal turquoise mines in the world, and until now very little definite information respecting them has been available. They are situated in the Bâr-i-Madèn, a district of the Nishâpûr province, about 40 miles N.E. of Sabzvâr and 32 N.W. of Nishâpûr, and at a height of 4,800 to 5,800 feet above sea-level. The turquoises occur in veins in a ridge of porphyries, greenstone, and altered limestones and sandstones. These veins run parallel to the strike of the stratified rocks—N. 70° E., to S. 70° W. A salt mine and a lead mine are worked in the same locality, but the turquoise mines keep by far the greater number of the inhabitants employed. Besides the vein mines, of which there is a considerable number, there are the Khâkî mines, which are opened out in the *débris* and rubbish heaps of the others, and which sometimes yield some of the finest stones. There are three classes of turquoises—(1) the Angushtarî, which include all those of good and "fast" colour and of favourable shape; they are sold by the piece at all sorts of prices, according to size, quality, and "zât" or lustre (£8 to £2,000); (2) the Bârkhâneh stones, which are sold by weight, and are of four standards, worth at the mines £90 for the highest to £4 for the lowest per pound. All stones of the third and fourth classes are called Arabî turquoises. The mines since 1882 are in the hands of a Persian company holding a concession from the Shah for fifteen years, and General Hontum Schindler was their manager till 1883. The total income of the company in the latter year was £6,666, and the expenditure about the same. G. A. L.

USEFUL MINERALS OF NEW ZEALAND.

Eighteenth Annual Report on the Colonial Museum and Laboratory. By William Skey. *pp.* 39-68. *Wellington, N.Z.*

Analysis are given of—

1.—*Coals*—

From Malvern Hills: altered brown coal and anthracite.
„ Reefton: brown coal of superior quality, and pitch-coal.
„ Maerewhenua (Duntroon): brown coal.
„ Picton: earthy brown coal and bituminous coal.
„ Whangarei (North): good brown coal.
„ Masterton: brown coal.
„ Kaitangata: pitch-coal.
„ Tokangamutu: fairly good brown coal.
„ Glenroz (Matahitahi): very valuable steam coal.
„ Hampden „ „

2.—*Iron Ores*—

From Hope: ironsands (magnetite and hæmatite).
„ Heapley district: ironsand (magnetite and ilmenite).
„ Malvern Hills: spathic ore, yielding 40·38 per cent. of iron.
„ Westport district: a "wash" of mixed hæmatite and magnetite, yielding from 66·4 to 67·6 per cent of iron.
„ Greymouth: hæmatite, yielding 51·22 per cent. of iron.
„ Pahua district: impure hæmatite, yielding 15·26 per cent. of iron.
„ Whangamoa district: magnetites, yielding from 65·52 to 54·20 per cent. of iron.

3.—*Manganese Ores*—

From Nelson district: bog manganese, containing 76·45 per cent. of the oxides of manganese.

„ Pahua: an iron rock charged with manganese.

„ Terawhiti: containing only 37·6 per cent. of the mixed oxides.

„ Nelson: very pure manganite, containing 90·06 per cent. of manganese sesquioxide. This ore was mistaken for tinstone.

4.—*Chrome Ores*—

From Dun Mountain district, Nelson: containing from 18·61 to 65·60 per cent. of chromic oxide.

„ Whangamoa district: with 31·35 of chromic oxide.

„ Aniseed Valley: with 41·06 to 45·40 per cent. of chromic oxide.

5.—*Antimony Ore*—

From Picton: with 38·57 to 68·83 per cent. of antimony.

„ Nelson „ 71·51 per cent. of antimony.

„ Otago „ 66·05 „ „

6.—*Mercury*—

From the upper part of the Waishine River, Wairarapa: cinnabar in a rolled fragment of greenish sandstone.

7.—*Copper Ores*—

From the Nelson district: cuprite, chalkopyrite, bornite, carbonate, and native copper, comprising some exceedingly rich ores from several localities.

„ Conachy Creek: copper pyrites, containing 18·33 per cent. of copper, from the Ben Lomond lode.

8.—*Graphite*—

From the "New Lease," Nelson: a good commercial "black lead," with 34·40 to 51·62 per cent. of carbon.

„ Collingwood: with 33·62 per cent. of carbon.

9.—*Gold and Silver*—

From the Terawhiti and Anatori quartz lodes, including some very rich ores from the former. G. A. L.

GEOLOGY OF COCHIN-CHINA.

Esquisse Géologique de la Cochinchine Française du Cambodge (province de Pourzat) et de Siam (province de Battambang). By — Petiton. *Bulletin de la Société Géologique de France, Sér.* 3, *Vol. XI., pp.* 385–399. *Plate VIII.*

An account of the author's geological explorations in French Cochin-China, Cambodia, and Siam. The general physical features of the countries visited are described, and their relations to the rocks are sketched out. Most of the rocks met with are unstratified, and where sedimentary beds occur no fossils (one specimen of Encrinite excepted) were found. Porphyrites, granites, diorites, and diabase are the igneous rocks recorded. The stratified deposits include two great formations on the west coast, one arenaceous and the other calcareous, and much alluvial matter in the south of the Peninsula.

The mineral resources of the region are touched upon, and comprise:—Iron ore, in the Province of Bienehoà, and in Phu-Quoe or Trone Island, and lignite in the same island. The existence of gold mines in the Province of Bienehoà and of silver mines in that of Ha-Tiene is regarded as doubtful by the author. A good map, partially coloured geologically, accompanies the paper. G. A. L.

PENNSYLVANIAN COAL-FIELDS.

Brief description of the Anthracite Coal-fields of Pennsylvania. By Charles A. Ashburner. *Proceedings of the Engineers' Club of Philadelphia, Vol. IV., pp.* 177–208. *One Map (Plate XI.) and three figures in text.*

A very clear and concise account of the geography, history, and geology of the region, with notices of the methods of mining adopted and statistics of production. The whole forms a convenient epitome of the results of the Second Geological Survey of Pennsylvania; but, being itself highly condensed, it cannot be usefully abstracted.

G. A. L.

IRON ORES OF VIRGINIA.

The Iron Ores of the Valley of Virginia. By Andrew S. McCreath. *Transactions of the American Institute of Mining Engineers, Vol. XII., pp.* 17–26.

The "Valley of Virginia" is about 330 miles long and 10 to 20 miles in width. It extends from the Potomac to the Tennessee line, and traverses the States of New York, New Jersey, Pennsylvania, Maryland, Virginia, and Tennessee. The ores referred to in this paper are almost confined to the Primal or Potsdam sandstone formation and to the lower Silurian limestone formation, which are the two chief series of the region.

The Primal or Potsdam sandstone formation is divided into: 1.—*Lower slates*, in which occurs the so-called "specular ore" of the Blue Ridge, really a red hæmatite often of considerable thickness and good quality. 2.—*Sandstones*, in which is found a close-grained, brittle, dark brown hæmatite, fully 10 feet thick on the Vesuvius property in Rockbridge County. 3.—*Upper slates*, which form one of the richest repositories of brown hæmatite in Virginia, from which the blast furnaces of Pennsylvania and other districts have been and are still largely supplied. Rich manganese deposits also occur in these rocks.

The Great Limestone formation (Lower Silurian) yields a large amount of brown hæmatite in irregular deposits, often of great extent. In South-West Virginia these ores have furnished practically the whole of the stock to the charcoal furnaces of the district.

Full analyses are given, the results of which may be summarized as follows:—

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Metallic iron	40·100	52·425	52·275	52·725	54·350	52·200	53·350	56·500	51·175	56·050	64·650
Metallic manganese ..	·030	·302	3·216	1·275	·396	1·419	·036	·072	·229	·060	·008
Sulphur	·903	·005	·021	·010	·016	·016	·063	·071	·105	—	—
Phosphorus	·265	1·466	·102	·266	·195	·194	·075	·048	·197	·036	·022
Phosphorus in 100 parts iron	·660	2·796	·195	·504	·358	·371	·140	·085	·384	·064	·034

The localities are:—

1.—The "Pollard Cut," on the Arcadia furnace property in Botetourt County.
2.—The "Cold Short" bank on the Vesuvius property, Rockbridge County.
3.—Donovan property, Beverley Ore Company, Page County.
4.—Fox Mountain Bank, Shenandoah Iron Company, Rockingham County.
5.—Buena Vista Furnace property, Rockbridge County.
6.—Houston mines, Nos. 5 and 6 openings, Botetourt County.
7.—Rich Hill, or Forney property, near New River.
8.—New River Mineral Company's property (Van Liew's).
9.—Speedwell Furnace property.
10.—Golleher Bank, Washington County, Virginia. Magnetic iron ore.
11.—Crockett Bank, Sullivan County, Tennessee. Red hæmatite. G. A. L.

ORGANIC MATTER FORMING IN A COAL-PIT.

Note sur un Dépôt de Matière organique trouré dans les mines de Houille d'Ahun. By — de Grossouvre. *Annales des Mines, Sér.* 8, *Vol. V., pp.* 365–369.

An account of a white glairy substance forming on the walls of a water-bearing fissure in the workings of a colliery at Ahun (Department of La Marche, in France). The analysis given shows it to be albuminoid matter, closely resembling vegetable or animal albumen, and to be identical with a gelatinous substance often met with in connexion with mineral springs (especially hot springs) and known by a variety of names, *e.g.*, Pyreneine, Baregine, Sulphurine, Glairine, etc. The author regards the substance in question as being probably due to purely chemical reactions, without the intervention at any time of either vegetable or animal life. G. A. L.

IRON ORES OF THE EASTERN STATES.

Geologico-Geographical Distribution of the Iron Ores of the Eastern United States. By John C. Smock. *Transactions of the American Institute of Mining Engineers, Vol. XII., pp.* 130–144.

In this paper the iron ores of the region are grouped according to the age of the rocks among which they are found, thus—

Laurentian.—Immense beds and veins of magnetite and hæmatite in the granitic and gneissic rocks of Maine, New Hampshire, Connecticut, the Lake Champlain region, the Highlands of the Hudson, New Jersey, Pennsylvania, Maryland, Virginia, North Carolina, Eastern Tennessee, Georgia, Alabama, and, possibly, of Arkansas and Texas.

Huronian.—Though magnetite occurs, specular ore is more characteristic and typical of this division. In some cases it is impossible to separate the Huronian from the Laurentian ore deposits. Beginning again at the north-east the following States possess iron ore of this age:—Connecticut and elsewhere in New England (where, however, they are not made use of), New York, New Jersey (red hæmatite), Virginia, North Carolina, South Carolina, Missouri (including the Iron Mountain, Pilot Knob, etc.), Michigan, Wisconsin, and Minnesota. The great development of the Huronian ores in the west, and the large production of the Laurentian districts in the east are noteworthy.

Lower Silurian.—Mostly brown hæmatites or limonites, alteration products of other compounds of iron, in the following States:—Maine, Vermont, and New Hampshire, Massachusetts, Connecticut, New York (including the famous Salisbury and Amenia beds), New Jersey, Pennsylvania, Maryland, Virginia, Tennessee, North Carolina, Georgia, Alabama, Missouri, and Wisconsin.

Upper Silurian.—Not so rich in iron ores as the Lower Silurian. The *fossil ore*, an oolitic red hæmatite, is characteristic of the Clinton group, and occurs along its outcrop from New York almost without break to Alabama, and in Pennsylvania, Virginia, Tennessee, North-West Georgia, Eastern Kentucky, Western Virginia, Ohio, and Wisconsin. Ore is also found in the Lower Helderberg and Oriskany groups.

Devonian.—Very poor in iron ore, what there is being chiefly carbonates.

Subcarboniferous.—Limonite and carbonates principally, in Pennsylvania, Kentucky, Ohio, West Virginia, Indiana, Illinois, Iowa, Missouri, and Arkansas.

Carboniferous.—Also chiefly limonite and carbonates, in Pennsylvania, Ohio, West Virginia, and Kentucky.

Trias.—The black-band ore at Egypt in North Carolina is the only worked deposit of this age.

Cretaceous, Tertiary, and *Recent.*—Bog-ores and limonites, in Maryland, Delaware, Tennessee, and throughout the Atlantic coast border and in the Gulf States.

G. A. L.

HUNGARIAN FIRE-CLAY.

A Királyhágó és a Sebes-Körös völgy Bucsától-Révig. By J. Von Matyasovszky. *Földtani Közlöny, Vol. XIV., pp.* 191–196.

This is a report of the Government Geological Survey of Hungary on the rocks of Királihágó and the Körös Valley, from Bucsa to Rév. With the exception of an isolated mass of igneous rock near Korniczel, the rocks of the country are beds of Jurassic, Cretaceous, and Upper Tertiary age. Attention is directed to the fire-clay of Rév and Sonkolyos, which has been constantly worked since last century, and is widely known for its excellent quality. Owing to the improper manner in which this valuable deposit has been mined the original locality (the Pozsorita Mountains) is now all but exhausted. The author points out the occurrence of similar clay elsewhere in the region. In all cases the fire-clay is of Jurassic age. G. A. L.

CANADIAN APATITE.

The Apatite deposits of Canada. By Dr. T. Sterry Hunt. *Transactions of the American Institute of Mining Engineers, Vol. XII., pp.* 459–468.

Apatite was first recognised as occurring in quantities in the Laurentian rocks of Canada as early as 1847 by Dr. Sterry Hunt. Deposits of the mineral of economic importance are now known in many localities, chiefly in the Province of Ontario, including parts of the Counties of Lanark, Leeds, and Frontenac, and in Ottawa County of the Province of Quebec. In all cases the apatite is found both in veins and bedded in augitic rocks belonging to the Laurentian gneiss series of the region. In the bedded deposits the apatite is generally compactly crystalline, free from admixture (excepting iron pyrites and, more rarely, layers of magnetite), and are, so far as they have been explored, fairly constant. The veins of apatite, on the other hand, are very commonly mixed to an injurious extent with other minerals, and are very variable in width and continuity. The amount of apatite shipped from Montreal in 1883 reached 17,840 tons, of which 1,516 tons were for Hamburg, 650 for Stockholm, and the rest for British ports. Of the whole amount 15,000 tons came from Quebec, the rest from Ontario. In the present year (1884) the author states that 24,000 tons will be shipped from Montreal. The cost of production is estimated at from $2 to $8 the ton, leaving, at the present market price, a considerable profit. A very large amount of available apatite remains untouched. G. A. L.

THE ALABAMA COAL-FIELDS.

Contributions to the Geology of Alabama. By E. J. Schmitz. *Transactions of the American Institute of Mining Engineers, Vol. XII., pp.* 144–172. *One Plate.*

This paper is a very full summary of an unpublished treatise on the geological formations and minerals of Alabama. "The future importance of this State," says the author, "lies in its Middle Zone, with its great wealth of iron ore and its supplies, near the ores, of good coking coals." The coal-fields are an extension of the great Appalachian field. They occupy a series of synclinal folds, and are divided as follows:—

1.—The *Spurs of the Cumberland Mountain Coal-field*, of small importance, consisting of some 500 feet of Coal-Measures, with, in parts only, one or two workable seams 2 to 4 feet thick.

2.—The *Warrior Coal-field*, in the form of an equilateral triangle, about 5,000 square miles in area, with nine workable seams 3 to 12 feet thick in 1,800 to 2,000 feet of strata. Five to six feet of good coal seems to be the maximum found in any seam. Many of the coals coke well.

3.—The *Raccoon* and *Sand Mountains Coal-field*, of small area, with two or three workable seams in 600 to 700 feet of strata.

4.—The *Cahaba Coal-field*, about 250 square miles in area, with a maximum of about fourteen seams, of which seven, together 24 feet thick, are workable.

5.—The *Coosa Coal-field*, variously estimated at 100 and 200 square miles, is at present but slightly known. Three or four workable seams have been noticed.

6.—The *Lookout Mountain Coal-field*, also insufficiently explored, contains (as at present known) but one workable seam in 600 or 700 feet of coal-measures.

Analyses of the coals and iron ores, as well as of the chief limestones, dolomites, marbles, copper ores, kaolin clays, and manganese ores of the State are given in nine elaborate Tables.

Besides the Coal-Measures, the other rocks of Alabama are of Subcarboniferous, Silurian, Huronian, and Laurentian age in the Middle and North-western Zone, while Cretaceous, Tertiary, Drift, and Alluvial deposits occupy the Southern Zone or remaining half of the State. G. A. L.

COPPER BELT OF SOUTH MOUNTAIN, PENNSYLVANIA.

(1) *The Copper deposits of the South Mountain.* By C. Handford Henderson. *Transactions of the American Institute of Mining Engineers, Vol. XII., pp.* 85–90. *With a Map.*

So far this belt of copper-bearing rocks has been studied almost exclusively in portions of Adams County and Franklin County; but it can be traced into Maryland. The rocks are now known to be of Huronian age and, therefore, quite distinct from the copper horizon of the Lake Superior region with which they were formerly compared. The actual cupriferous rock is an epidosyte (*i.e.*, a mixture of quartz and epidote) impregnated with native copper, and often coloured by green or blue carbonates. It lies between chloritic schists and orthofelsite, locally known as "porphyry." Determinations of the amount of metallic copper at four localities are given, the percentages being 5·83, 16·44, 1·82, and 5·93 respectively. For more than seventy years mining operations have been carried on at various points of the belt, but without much success. Many thousand tons of the copper-rock are said to be easily available above water-level, but the ore is generally regarded as too poor for profitable working.

(2) *An hypothesis of the structure of the Copper Belt of the South Mountain.* By Dr. Persifor Frazer. *Same publication, pp.* 82–85. *One figure in text.*

The author regards the epidotic quartz carrying the native copper as the infillings of fissure-faults with varying up or downthrows, of which the result is to bring the orthofelsites and the chlorite-schists together unconformably. G. A. L.

CONCEALED COAL-FIELD IN THE SOUTH OF FRANCE.

Note sur le sondage de Toussieu (Isère). By F. Fontannes. *Bulletin de la Société Géologique de France, Sér.* 3, *Vol. XI., pp.* 241–242.

This is an account of one of a series of borings put down under M. Grand 'Eury's direction, to prove the Coal-Measures in the neighbourhood of Heyrieu. In this case the Tertiary beds of the region are of quite exceptional thickness, the marine *Mollasse* (Miocene) being at least 236 metres (756 feet). Eocene beds occur below these, and are some 55 metres thick. They lie directly upon the Coal-Measures, which were struck at a depth of 322 metres (1056·5 feet). G. A. L.

VIRGINIAN PYRITES.

The Pyrites deposits of Louisa County, Virginia. By W. H. Adams. *Transactions of the American Institute of Mining Engineers, Vol. XII., pp.* 527–535. *With Map and Plate of sections.*

These deposits belong to the class of pyritous ores found along the Atlantic seaboard in Georgia, North Carolina, Virginia (near Lynchburg), Maryland (Cecil County), New Jersey, New York, Connecticut, Massachusetts, Vermont, New Hampshire, Maine, and Canada. The iron pyrites is stated to underlie the hæmatite ores of the region, which the author regards as derived from sulphide of iron. Details of the Arminius mine are given in illustration of the nature of the deposits, which are lenticular beds of pure pyrites, from 20 to 36 fathoms in thickness, and 170 to 200 fathoms in length. These masses of ore occur among highly tilted clay-slates, talcose, and steatitic schists and other metamorphic rocks, within an area of some 1,300 or 1,400 square miles. As regards the value of the deposits the following Table of analysis is given to facilitate comparison with the best known foreign ores :—

	Sulphur.	Iron.	Copper.	Lead.	Zinc.	Lime and Magnesia	Arsenic.	Insoluble.
Arminius Copper Mines	49·27	43·62	1 50	—	·38	1·32	—	4·23
Sulphur Mines Co., of Va.	50·00	43·00	—	—	—	—	—	6·02
Wicklow, Ireland ...	38·79	36·06	2·57	1·80	—	—	·39	19·71
Norway	47·55	41·92	·90	—	1·26	3·38	—	6·15
Rio Tinto, Spain ...	47·87	40·93	3·82	·62	·10	·19	·26	5·42
San Domingo, Portugal	46·00	43·50	3·10	1·60	·32	—	·30	5·18
Capelton, Canada ...	46·60	43·10	3·15	·45	·15	1·30	·15	5·10

In no case has arsenic been found in the pyrites from this district. The extent of the deposits is said to warrant contracts for 1,000 tons a-day for many years to come. The mines are 60 miles from tide-water at Richmond, Va., and 130 miles from Newport News, Va., both of which places are termini of the Chesapeake and Ohio Railway. From Newport News to Liverpool is 3,100 miles, and for half the year ores can be shipped as ballast in cotton ships for 2s. to 3s. as against 14s. from Huelva, Spain.

G. A. L.

SILVER AND IRON IN MEXICO.

Certain Silver and Iron Mines in the States of Nuevo Leon and Coahuila, Mexico. Transactions of the American Institute of Mining Engineers, Vol. XII., pp. 537–569. *With two Plates of Views and nine folding Maps and sections.*

This paper consists of reports on a number of mines situated in the northern part of the States of Nuevo Leon and Coahuila, between lat. 26° and 27°. They can be grouped, according to the ranges in which they occur, into four classes:—(1) Those in the Sierra de la Yguana; (2) those in the Sierra de Gomez; (3) those in the Cerro Mercado; and (4) those in the Sierra de San Márcos. The first two belong to the Villaldama district, and the others to that of Monclova. The mines named the *Arroyo*, the *Montaños*, and the *Pinitos* are in the former district, and are opened out on veins and flats in a very prevalent crystalline limestone of supposed Upper Carboniferous age. The mines of the Monclova district are: that of *La Paloma* in the same country rock, the *San Rafael*, where the vein lies in granite or "heavily-bedded" gneiss, but very

near to contact with the limestone; and lastly, the *Riojas* mine, situated in a mass of intrusive granite. A condensed Table of 28 analyses of the ores from the different mines (except La Paloma, which is an iron mine) is given, showing the amount of silver in ounces per ton to be, for the Arroyo mine, 15 to 33·5; the Montaños mine, 2 to 8; the Pinitos mine, 1 to 849·8; the Riojas mine, 29 to 527; and the San Rafael, 1 to 304.

The future importance of the iron ores depends greatly on the presence of available fuel. At present the charcoal of the region is used, but trees are not plentiful and will soon not satisfy the demand. Monclova is about 70 miles south-west of the large coal-fields opened out near Progreso by Dr. H. B. Butcher, and could without difficulty be connected with them by rail by way of the Hermanos Pass and the Rio Salado. Analyses of the coal are given. A list of barometer levels, taken by the author, is appended. G. A. L.

IRON ORES OF COLORADO.

Notes on Iron-ore deposits in Pitkin County, Colorado. By W. V. Devereux. *Transactions of the American Institute of Mining Engineers, Vol. XII., pp.* 638–641.

The author records the occurrence of three deposits in the precipitous ranges forming spurs on the Pacific slopes of the Rocky Mountains. The first is a bed of limonite of considerable area, thin at the edges and 3 feet thick towards the centre. This sheet of ore lies upon the flank of a high mountain at the base of Hayden's Peak, and rests unconformably upon the eroded surface of the rocks. The ore is filled in places with impressions of spruce leaves, similar to those of the growing forests around the spot. Analyses give 55 per cent. of metallic iron, and 8 per cent. of silica; and, notwithstanding its obviously recent origin, it is hard and compact. A very similar ore is described as filling a fissure vein, in quartzite, a few miles off. In this case the limonite was botryoidal, and cavities within it were lined with small quartz crystals. The vein was 2 feet thick and could be followed some distance.

The third deposit referred to is the only one of special economic value. It appears to be a mass of magnetite, situated about 12 miles up the same valley, and extending from an elevation of about 11,000 feet for more than a mile across a spur of Taylor Range. The country rock is limestone, supposed to be Silurian in age. The outcrop of the body of ore is several hundred feet in width, and is well exposed. An analysis shows 68·79 per cent. of iron, 1·7 per cent. of silica, and 0·24 of sulphur. This magnetite has been used by the writer as flux in smelting argentiferous lead ores with baryte gangue, iron-malte being one of the products, the separation of the sulphur from which is easy. G. A. L.

THE NORTHERN AND PAS-DE-CALAIS COAL-FIELD.

Note sur les Bassins houillers du Nord et du Pas-de-Calais. Remise a la délégation de la Commission des 44, 10*th October*, 1884, *Sér.* 2, *pp.* 95–101.

There are 43 royalties, 34 of which are being worked. The area is 121,796 hect. (470 square miles).

Workings.

1882	... ...	9,484,021 tons.
1883	... ...	9,944,868 ,,
1884	estimated	9,500,000 ,,
1885	do.	9,000,000 ,,

Selling Price.

11·17 francs (8s. 11·23d.), that for the whole of France being 12·36 (9s. 10·65d.)

The average selling price is in the Loire, 15·02; Saône and Loire, 13·58; the Gard, 12·58; and in the Allier, 12·52 francs per ton.

The average selling price at one important colliery in the Northern coal-field for the last 30 years has been—

1854 to 1863	... ...	12·64 francs	(10s. 1·34d.)
1864 to 1873	... ...	12·63 „	(10s. 1·24d.)
1874 to 1883	... ...	12·00 „	(9s. 7·2d.)
Average	... ...	12·55 „	(10s. 0·48d.)

Workmen Employed.

Below ground	38,855 =	78 %
At bank	10.204 =	22 %
Total	49,059 =	100

Persons depending upon the Mines.

It is calculated that there are 4·81 individuals in a family, and that each family furnishes 1·7 workers. We have, then, 27,100 families and a population of 230,000* individuals.

Production and Wages per Workman Employed.

Belowground ...	264 tons ...	1,182 francs (£47 5s. 7d,)	per annum.
At bank	...	684 francs (£27 7s. 2d.)	„
Both ...	205 tons ...	1,072 francs (£42 17s. 7d.)	„

Wages in Detail.

Hewers by the piece...	46 % ...	4 to 6 francs ...	average 4·8 francs.	
„ by the day ...	7 % ...	3·5 to 3·75 „ ...	„ 3·6	„
Putters, etc.	13 % ...	2·5 to 3·5 „ ...	„ 3·0	„
Boys, etc.	12 % ...	1·5 to 2·0 „ ...	„ 1·7	„
In the pit ...	78 % ...	... ...	„ 3·92	„
At bank	22 % ...	... ...	„ 2·27	„
	100		Average 3·56	

Houses.

14,000 have been built, sufficient to accommodate more than 50 per cent. of the workmen. They are let to the workmen at from 3 to 6 francs (2·4s. to 4·8s.) per month, according to size. Similar private houses let at three times the price.

Miners' Institutions.

Relief funds, co-operative stores, and schools have been established. In 1883 a detailed examination of the institutions supported by ten of the principal Coal Companies (employing 33.000 out of the 46,000 workmen of the Northern Coal-field) was made. Nine of them had a relief fund, of which the receipts in 1882 were:—

Workmen's contributions... ...	603,097 francs . .	73 % ...	(£24,124)
Masters' „	218,037 „ ...	27 % ...	(£8,721)
	821,134 „	...100 ...	(£32,845)

* 130,000 (?).—J. H. M.

During the same year the ten companies distributed amongst the workmen:—

		Francs.		Francs per Man.
1.	Sick and injured	576,879	...	17·56
2.	Pensions to men, widows, and orphans ...	470,918	...	14·33
3.	Medical attendance and drugs	333,277	...	10·14
4.	Schools	221,776	...	6·75
5.	Hospitals, funerals, etc.	53,908	...	1·64
6.	Sundry assistance	80,682	...	2·46
7.	Firing	1,067,137	...	32·48
8.	Loss of interest on houses	741,215	...	22·56
	Total ... ... (£141,815)	3,545,792	...	107·92
	Less workmen's contributions	603,097	...	18·36
	(£117,708)	2,942,695	...	89·58

And 89·58 francs added to the annual wage gives 1,162 francs (£46 9s. 7d.) as the gross average earnings of each workman, equal to 3·77 francs (3s. 0·19d.) per day.

Accidents.

The statistics for the last 10 years give 1 workman killed in—

Prussia	per 345	persons employed.
England	„ 424	„
Belgium	„ 419	„
France	„ 476	„
Northern Coal-field ...	„ 628	„
Northern Railway ...	„ 612	„
Fishing-boats	„ 109	„

Profits in 1882.

20 mines have made	15,973,101	francs	(£638,924)
14 „ have lost	1,984,390	„	(£79,375)
34	13,988,711	„	(£559,549)

Equal to 1·47 francs (1s. 2·11d.) per ton drawn to bank. The profit for the whole of France was 1·83 francs (1s. 5·56d.) per ton.

Net Cost.

The selling price was	11·17	francs	(8s. 11·2d.)
Less profit	1·47	„	(1s. 2·1d.)
Net cost	9·70	„	(7s. 9·1d.)

The net cost for the whole of France was 10·53 francs (8s. 5·08d.)

Capital Expenditure, etc.

The yearly output of 10,000,000 tons has absorbed a capital of 300 to 350 millions of francs (£12,000,000 to £14,000,000), and this must be increased to from 400 to 450 millions of francs (£16,000,000 to £18,000,000) if we take into account the money sunk in unsuccessful attempts to win the coal, which have, however, furnished reliable data for subsequent successful undertakings. The profit, therefore, already mentioned, of 14,000,000 francs, is equal to a dividend of 4 per cent upon the capital expenditure (350 millions of francs).

J. H. M.

THE IRIDIUM INDUSTRY.

By W. L. DUDLEY. *Transactions of the American Institute of Mining Engineers, Vol. XII., pp. 577–587. Four Engravings in the letterpress.*

Iridium is found in California, Oregon, Russia, East India, Borneo, South America, Canada, Australia, and in certain parts of France, Germany, and Spain; but the principal sources of supply are the Ural Mountains in Russia and the placer gold-washings of California. It is usually found with either platinum or gold; and its specific gravity, 19·3, being nearly the same as the latter, it is impossible to separate them by washing; and amalgamation, or the dissolving of the gold in aqua regia, has to be adopted. In the mints it is separated from gold by melting and allowing the metal to remain for some time in the crucible, when the iridium sinks to the bottom and the gold can be poured off, any gold remaining being dissolved out.

In Russia it is contrary to the law to be in possession of iridium ore; as, alloyed with gold, it finally found its way into the mint and damaged the machinery.

Until lately (on account of the difficulty of melting) iridium was only used for pointing gold pens; but about four years ago Mr. John Holland discovered that by heating the ore in a Hessian crucible to a white heat, adding phosphorus, and continuing the heating for a few minutes, he obtained a perfect fusion of the metal, which could be poured out and cast. Since this date it has come more largely into use for stylographic pen points, wire draw-plates, knife-edges for fine scales, hypodermic needles, and for other purposes where hardness, durability, and non-corrosibility are required. It is also used for the contact points of telegraphic apparatus; and when dephosphorized, by heating in a bed of lime, the author has used an iridium electrode upon the negative of an arc light with success. He is now experimenting on plating with iridium.

The author describes, with the aid of some engravings, the process of the manufacture of the Mackinnon stylographic pen-points, the first practical application of Mr. John Holland's discovery. J. H. M.

TAMPING DRILL-HOLES WITH PLASTER OF PARIS.

By FRANK FIRMSTONE. *Transactions of the American Institute of Mining Engineers, Vol. XII., pp. 574–577.*

The author was engaged in removing a large mass of iron that had accumulated in a furnace at Glendon. Atlas powder was used, and the holes made with Rand drills. So long as the iron was at all uniform in hardness these worked very well; but when it was not, as was often the case, the holes were frequently blocked when little over a foot deep. It was important, therefore, to have good tamping. This was found in plaster of Paris, which was poured into the hole mixed with clean dry sand to reduce the quantity required. Experiments were previously made, proving that the rise in temperature when boiled plaster solidifies would not be sufficient to fire the exploders.

In the discussion that followed, Dr. Raymond called attention to the importance of firing shots (at least those which are compounds of nitro-glycerine) soon after tamping, because the rise in temperature, though it may not be sufficient of itself to fire the charge, is often sufficient to set up a generation of gas which will in time bring the pressure which will cause explosion. He mentioned a case in point, on the Pacific coast, in 1869. J. H. M.

MANUFACTURE OF PATENT FUEL.

Machine a double compression pour l'agglomération de la houille. Le Génie Civil, Tome VI., p. 117.

Briquettes of patent fuel should be of uniform weight, perfectly compact, impervious to moisture, and of almost mathematical uniformity in the percentage of ash and of volatile matter. Messrs. Biétrix, of Saint Etienne, have recently erected complete plant for its manufacture, as hereinafter described.

Preparation of the Paste.

The coal after being washed, to remove all stones, must be rendered sufficiently plastic by the addition of the minimum quantity of tar. It has been the custom to use steam for mixing the materials, but the moisture added to the coal by its use prevents the manufacture of a compact briquette.

In the present instance, a circular furnace is employed for heating and drying the coal, which is laid upon a rotating bed provided with a suitable arrangement of rakes and vanes for turning the coal over. The fire is situated at one side, and provides the means for heating and drying the coal; the flames pass over the surface of the coal and thence under the circular plate to the chimney. The coal is conveyed from the hopper to the furnace by an endless elevator, discharging into a screw which conveys it to the furnace. After leaving the furnace, the coal enters a screw, where it is mixed with the broken pitch which has been conveyed to that point by a suitable arrangement of elevator, belt, and spout.

Compression of the Paste.

The construction of the press, the invention of M. de Couffinhal, can scarcely be explained without reference to the drawings. The dies are contained in a rotating plate, which is only driven when the plungers are out of the dies. The dies are attached to a beam, moved at one end by geared cranks and connecting rods, and attached at the other end to an hydraulic press. By this arrangement all danger of damage to the press is avoided, which might otherwise occur; for instance, when a hard body is accidentally found in the paste.

After being mixed with the pitch, the coal is passed through a pug-mill, and finally reaches the dies, each of which is filled in succession by a rotating scraper. Whilst in the dies, the paste is thrice compressed. first by the upper plunger, second by the lower plunger rising until the pressure is equalized, and third, when the hydraulic piston is forced into the press. The removal of the briquettes is effected by an endless belt.

Advantages of the System.

The high temperature of the furnace, or kiln, drives off the moisture in the coal, and thereby the produce is of better make, and at the same time it softens the cementing material of the coal and there is a saving of pitch. The press is of simple construction and all parts are constantly in view of the engineman. The briquettes are of regular size and homogeneous, being produced under a pressure of from 3,500 to 4,500 pounds per square inch; their surface is grooved, which facilitates the rupture of the fuel when placed in the fire.

Cost of Workmen and Fuel.

These charges will evidently vary according to the country in, and circumstances under which the manufacture is carried on.

The workmen required when producing 50 to 55 tons of briquettes (weighing 6¾ lbs. each) per day, is—

1 engineman in charge,
1 fireman for the boiler,
1 fireman for the furnace,
1 labourer at the coal hopper,
1 labourer at the pitch hopper,
4 boys to load the briquettes into wagons or place them in heaps,

or a wages cost of about 5d. per ton of briquettes made.

The maximum quantity of coal required as fuel will not exceed 2½ per cent., even with very wet coal, or about 4d. per ton.

If 2d. per ton be added for contingencies, the total cost is about 11d. per ton.

It is difficult to estimate the cost of pitch required, as the price varies very greatly according to the time and the place, and the weight required varies essentially with the quality of the coal employed. N. N. N.

SILVER-LEAD DEPOSITS OF NEVADA.

The Ruby-Hill Mines, Eureka, Nevada. Abstract of forthcoming Report by J. S. Curtis. *Science, New York, Vol. IV., pp.* 459-460, 1884.

The ore worked in these mines occurs in limestone of Tertiary or Pre-Tertiary age, which, with quartzite and shale, is the chief formation of the region. The vein itself is in contact with a large fault in these rocks partly filled with rhyolite. The ore, above the water-level, is principally galena, anglesite, mimetesite, and wulfenite, with very little quartz or calcite, the gangue being principally hydrated oxide of iron. Below the water-level, pyrite, arsenopyrite, galena, blende, and other sulphides, besides silver and gold, are found. The origin of the deposits is, like that of so many ore-masses in Western North America, referred to solfataric action.

From 1869 to 1884 the Eureka district has produced about 60,000,000 dollars of gold and silver, and about 225,000 tons of lead, the greater part of both amounts being derived from the Ruby-Hill Mines. G. A. L.

GOLD MINES OF GUADALAJARA.

Mines d'or de la Nava de Jadraque, Province de Guadalajara (Espagne). By — Autissier. *Bulletin de la Société de l'Industrie Minérale, Vol. XIII., Sér.* 2, *pp.* 125-145. *Plates.*

These mines are situated near the village of Jadraque, in the Atienza district of the province of Guadalajara, at a height of 1,400 metres (4,592 feet), among the spurs of the Guadarama, some 30 kilometres (18·6 miles) from the railway between Madrid and Saragossa, and communicating with it by a bridle-path only. Gold is recorded from the district by Pliny the Elder; but until 1876 no serious attempt was made to re-open any of the old mines. In that year a native of the region named Savas found some gold in one of the ancient workings, and since that time a number of concessions have been claimed in the neighbourhood. The principal of these are San Jose, California, Sol del Castellar, and Nuevo Hiendelaencina. These mines are described in the present paper; the two first-named more fully than the rest, being in active work. The precious metal occurs in fault-veins at San Jose and in certain zones of rock at California, but the prospect of finding it in large quantities is said to be slight. G. A. L.

GEOLOGY OF TASMANIA.

A Physical Description of the Island of Tasmania. *By the* Rev. J. E. Tenison-Woods. *Transactions and Proceedings of the Royal Society of Victoria, Vol. XIX., pp.* 144-166.

A concise summary of the whole subject. After describing the physical geography of the island, which is about 27,000 square miles in extent, the author enumerates the various geological formations recognized within it in the following order:—1.—*Granite, syenite,* and *porphyritic granite,* in connexion with which remarkable tin deposits have been found. 2.—*Metamorphic rocks,* chiefly quartzites and schists, alternating and passing one into the other. 3.—*Silurian* sandstones, clay-slates, grits, and limestones. Veins of galena occur in the latter, with calcite and quartz as gangue. 4.—*Devonian* rocks are doubtfully referred to as possibly present in Tasmania, at the base of the Carboniferous series. 5.—*Upper Palæozoic Carboniferous* [*sic*] rocks are very extensively developed. The marine fossils are of decided Palæozoic type, many indeed belonging to species common in the Carboniferous Limestone series of Britain; but the aspect of some of the fossil plants found in strata alternating with the marine beds is Permian (?) or Jurassic. Coal is more or less abundant in this series throughout the island, some of the seams being more recent than others (as, for instance, those of Fingal), "but the relative position has not been accurately worked out." 6.—*Carbonaceous Sandstone,* resembling the Hawkesbury rocks of Australia, occurs in the Oatlands district, and contains small seams of coal and carbonaceous shale. This series lies unconformably upon the Coal-Measures (No. 5). 7.—*Greenstone,* in sheets of later age than the carbonaceous sandstone. 8.—*Tertiary* marine and plant beds of Miocene and Pliocene age

The author concludes that "the evidence is in favour of Tasmania, like South-East Australia, being dry land during the latter part of the Mesozoic period."

G. A. L.

HUNGARIAN BUILDING STONES.

(1) *Jelentés az* 1883-*ik év Fehér-Körös közötti hegyvidéken és ar Arad-Hegyaljáu eszközölt földtani részletes felvételről.* *By* L. Lóczy. *Földtani Közlöni, Vol. XIV., pp.* 196-213, *with one figure in text.*

This is a report on the Geological Survey of the country between the Maros and the White Körös, and in the Arad-Hegyana. The following rocks are worked in the district as building stones and for lime:—1.—Augite-andesite at Apatelek. 2.—Granitite at Paulis-Baraczka. 3.—Fine and medium-grained greenstone at Paulis. 4.—Slate at Kuvin, much esteemed locally. 5.—Quartzite and quartzite-grit at Kovaszine, Világos, and Agris. 6.—Marble in the Kladova Valley. 7.—Clay and limestone at Agris.

(2) *Jelentés az* 1883 *év nyarán a Pilis hegységben eszközölt földtani részletes felvételről.* *By* Dr. Franz Schafarzik. *Same publication, pp.* 249-273.

A report on the Geological Survey of the Pilis mountainous district. The following rocks are worked:—1.—Thin-bedded Triassic limestone, used for street-flagging and also for the manufacture of cement. This occurs in the Szent-Lélek Valley. 2.—The Lindenberg sandstone, much used in Budapest for steps, balconies, etc. 3.—Other sandstones used for house-building crop out in the lesser Wachtberg and at Kesztöl. 4.—Potters' clay and limestone for burning in the neighbourhood of Pomaz.

G. A. L.

IRON MINES OF PALMESALADE.

Note sur le gisement de fer carbonaté de Palmesalade. By — PEYRE. *Bulletin de la Société de l'Industrie Minérale, Sér* 2, *Vol. XIII., pp.* 1–32, *Plates.*

The Palmesalade mines are situated at Affénadou, in the Department of Gard, and adjoin the well-known workings of the Grand' Combe. They date from Roman times, were opened out on a large scale in 1841, for thirty-two years fed the Tamaris furnaces, and were finally drowned out by the River Auzonnet in 1872. The present paper is a detailed report to the owners of the mine made in the latter year.

The deposit formerly worked consists of nine stratified masses (including a black band) of more or less lenticular form, interbedded amongst conglomerates, coals, and other strata of Coal-Measure age. The ironstone—a spathose carbonate of iron—is itself of sedimentary origin, and is due, in the author's opinion, to mineral springs in activity during later Carboniferous times. The carbonate often occurs in large crystals, and associated with it are such minerals as galena, quartz, blende, grey copper ore, chessylite, copper pyrites, iron pyrites, bournonite, pholerite, etc., all pointing to geyserian action. The deposit is limited, local, and littoral in character, and evidence is adduced to show that the springs by which it was formed were intermittent, and obtained the metallic impurities with which they were charged from vein-masses existing in older rocks. Analyses give the following percentages:—Clay and quartzose sand, 0·40 to 9·80; carbonate of protoxide of iron, 80·24 to 89·87; carbonate of protoxide of lime, traces to 2·04; carbonate of protoxide of magnesia, 0·39 to 2·64; alumina, 1·00 to 6·00; water and carbonaceous matter, 1·15 to 6·15. The total thickness of the ore-beds is 14 metres (45 feet). G. A. L.

EUROPEAN IRON ORES AND THEIR ORIGIN.

Etude sur les phénomènes métallifères. Les minerais de fer dans l'écorce terrestre. By STEPHEN CZYSZKOWSKI. *Bulletin de la Société de l'Industrie Minérale, Sér.* 2, *Vol. XIII., pp.* 257–385, 481–574. *One folding Table,* 31 *figures in text, and four folio Plates.*

This is the first part of a general treatise on iron ore deposits, and deals chiefly with their mode of formation and origin. The various ores are described in the order of their geological occurrence, beginning with the oldest. Their origin is referred to two causes: thermo-mineral springs, and thermo-mineral eruptions. Throughout the memoir De Lapparent's recent text-book of geology is used as the principal authority. The chief localities mentioned (many of them illustrated by maps and sections) are the following:—1.—*Archæan:* Sweden, Lapland, Algeria, the Val d'Aosta, Carinthia, and Gard. 2.—*Cambrian:* the Asturias, Brazil, Krivoï-Rog (Russia), Pazzano (Calabria). 3.—*Silurian:* Thuringia, the Asturias and Galicia, Brittany, Sagré (Maine-et-Loire), S. Leon (Sardinia), Vivero (Spain). 4.—*Devonian:* the Meuse district, the Erzberg of Styria. 5.—*Permo-Carboniferous:* Britain, Palmesalade (Gard), Osnabrück, Mansfeld. 6.—*Triassic:* Alais, Bessèges, Aujac, and Le Vigan (Gard), Balmelles (Lozère), Ailhon, Merzelet, and Montgros (Gard), Laurium. 7.—*Jurassic:* France, Britain, etc. 8.—*Cretaceous:* Métabief (Doubs), the Jura, Haute-Marne and Meuse, Champagne, the Ardennes, North Germany, Dauphiné, Haute-Savoie, etc. The Bauxite deposits of the South of France are described in this connexion. 9.—*Eocene:* the Jura and Bresse, Berry, Western France, Quercy. 10.—*Miocene:* Elba, Filfilah, Bilbao-Sommorostro, Carthagena, Granada (the Alpujarras), the Canigou (Pyrenees), Monte-Argentaro (Italy). 11.—*Pliocene:* Bougie (Algeria), the Landes, Scandinavia. 12.—*Igneous rocks:* Marbella (Spain), the Vosges, Giglio I. (Italy), etc. G. A. L.

NEW ZEALAND COAL.

(1) *On the Prospects of Coal occurring at the Whau.* *By* S. Herbert Cox. *Colonial Museum and Geological Survey of New Zealand Reports, Vol. XVI., Wellington*, 1884, *pp.* 10–11.

Account of an examination of the district of the Whau, Auckland, North Island, made in consequence of coal having been reported as present there. Nests and patches of coal with remains of broken plants do occur, but never more than a few inches in thickness. These deposits are in Lower Miocene beds. No Coal-Measures were found in the neighbourhood, and the reporter thinks there is no prospect of a workable seam of coal ever being met with.

(2) *On the so-called Hart's Coal-field, in the Malvern Hills, Canterbury.* *By* Dr. Julius von Haast. *Same publication, pp.* 16–19. *Two figures in text.*

This coal-field consists of a small outlier of Cretaceo-Tertiary coal-bearing rocks, containing several small seams of brown coal, which have been known and worked for some time, and one seam, 10 feet 6 inches thick, only quite recently discovered and now recorded for the first time. The thin coals had been found to change in character and become anthracitic in a certain direction. The cause of this alteration is now proved to be a dyke of amygdaloidal dolerite about 18 feet thick. A measured section of the coal-bearing beds is given, showing ten small seams of altered coal, besides the thick seam above-mentioned. An analysis of the latter yields the following percentages:—Fixed carbon, 43·21; hydro-carbon, 24·99; water, 23·79; and ash, 8·01. Evaporative power, 5·6 lb.

(3) *On the Geology of the Coal-bearing Area between Whangarei and Hokianga.* *By* Alexander McKay. *Same publication, No.* 16, *pp.* 110—134. *Map and five figures in text.*

This coal-field stretches from coast to coast across the north of the Auckland Provincial District, and is from six to twenty miles in breadth. The sedimentary rocks of the region are as follows:—

Cretaceo-Tertiary Group.

(*a*) Grey marls.
(*b*) Ototara and Weka Pass stone.
(*c*) Fucoidal greensands.
(*d*) Amuri limestone, chalk-marls, and chalk without flints.
(*e*) Marly greensands.
(*f*) Island sandstone (reptilian beds).
(*g*) Black grit and coal-formation. "These beds lie at the base of the series, and, as quartz conglomerates, fire-clays, and coal-seams, have an average thickness of 50 feet. The thickness of these beds is very variable, being but a few feet at Kamo and in some parts of the Kawakawa mine, while at Hikurangi there is apparently a considerably greater thickness than the average here given." (Page 117).

Sections of four diamond borings and one shaft at Kawakawa are given, and show, in the first case, no coal; in the second, two seams, one 6 inches, and the other 1 foot thick; in the third, one seam, 1 foot 3 inches thick; in the fourth, one seam, 1 foot thick; and in the shaft, three seams of hard coal, 4 feet 3 inches, 5 feet 9 inches, and 2 feet 9 inches thick. The sections all reach the Devonian slates, which form the floor upon which the Cretaceous coal-bearing beds rest, the depths being 596, 689, 321, 184, and 229 feet respectively. The shaft was sunk in 1879. G. A. L.

ORE-SEEKING WITH THE MAGNETIC NEEDLE.

El Magnetómetro, Aparato para la investigacion de minerales magnéticos y procedimiento empleado por el Profesor Thalen de la Universidad de Upsala en Suecia. By HORACIO BENTABOL. *Revista Minera y Metalúrgica, Sér. C., 3a Epoca, Vol. III., pp.* 2, 3.

An account of Professor Thalén's Magnetometer, a magnetic needle so suspended as to be capable, within certain limits, of both vertical and horizontal motion. This instrument is specially devised for the discovery of the position, shape, and depth of underground masses of magnetic ores, and is chiefly used for searching for deposits of magnetite in the Archæan rocks of Scandinavia and North America. By its means the following most important laws have been arrived at:—1.—The principal mass of ore will be met with at the point of intersection of the magnetic meridian (*i.e.*, the straight line joining the point of maximum and that of minimum deviation) and the neutral line. 2.—The distance from the surface to the centre of the mass of ore is double that between the said point and that of minimum deviation.

It is pointed out that as the ores of nickel, copper, zinc, etc., are often associated with the magnetite deposits of Sweden and elsewhere, the Magnetometer can be used in searching for the former as well as for the latter. G. A. L.

UNDERGROUND TEMPERATURE IN THE ARLBERG TUNNEL.

(1) *Ueber die Wärmeverhältnisse der Ostseite des Arlbergtunnels nach den Beobachtungen des Herrn k. k. Oberingenieurs und Sectionsleiters C. Wagner.* By H. B. VON FOULLON. *Verhandlungen der k. k. geologischen Reichsanstalt,* 1884, *pp.* 333, 334.

(2) *Ueber die Wärmeverhältnisse in der Osthälfte des Arlberg-Tunnels.* By J. WAGNER. *Jahrbuch der k.k. geologischen Reichsanstalt, Vol. XXXIV., pp.* 743–750, *with Tables and two Figures in text.*

The results of carefully-conducted observations of temperature of air and rock, in the eastern half of the Arlberg Tunnel, are given in a Table, from which the following rock-temperatures at every 100 metres in depth (109·4 yards) are extracted:—

Depth.	Temperature of the Rock.	
	Celsius.	Fahrenheit.
Metres.	Deg.	Deg.
100 (328 feet)	8·9 =	47·9
200 (656 feet)	11·8 =	53·2
300 (984 feet)	12·5 =	54·4
400 (1,312 feet)	13·0 =	55·4
500 (1,640 feet)	13·3 =	55·9
„ (further from the mouth of the tunnel)	15·1 =	59·1
600 (1,968 feet)	15·7 =	60·2
„ (further from the mouth of the tunnel)	16·6 =	61·8
„ (still further)	16·0 =	60·8
700 (2,296 feet)	17·1 =	62·8
„ (further from mouth)	18·4 =	65·1

From the above an average increase of temperature downwards of from 0·77° to 0·86° F. per 100 feet may be inferred. A section showing the curve of the underground isotherm is given. G. A. L.

BELGIAN PHOSPHATES.

Découverte de Gisements de Phosphate de Chaux appartenant à l'étage Yprésien, dans le sous-sol de la ville de Renaix et dans celui de la région de Flobecq. By É. Delvaux. *Annales de la Société Géologique de Belgique, Vol. IX., Mém. pp.* 279–294.

The chief object of the paper is to record the discovery of phosphatic nodules in the Ypresian (Eocene) beds in the neighbourhood of Renaix and Flobecq. Several analyses are given showing the percentage of phosphoric acid to be from 19·35 to 24·55; but notwithstanding the large area over which these nodules are said to occur at this geological horizon, the discovery is stated to be at present of no commercial importance. A useful table is, however, appended to the memoir, in which are entered, in stratigraphical order, all the known phosphatic deposits of Belgium. This information may be summarized as follows:—

Geological Divisions.	Phosphatic Deposits.
Quaternary	... Derived nodules in gravels: Hesbaye, Hainault, and Limburg.
Tongrian...	... Nodules (often mistaken for septaria): Louvain and Groot-Spauwen.
Ypresian ...	... Nodules in the *Nummulites planata* beds and the underlying clay: Ypres, Louvain, Brussels, Flobecq, Renaix, and Grammont.
Cretaceous	... Conglomerates (*poudingues*) of Malogne and Pry; coprolite beds of Maestricht, etc.; brown chalk of Ciply, Mesvin, etc.; chalk of Obourg; marl of Autreppe; Hervian gyrolite marls; "Tourtia" of Tournai; Wealden (?), selvages of metalliferous veins at Baelen, and in yellow clay with limonite of the same age at Ramelot.
Jurassic ...	... Lias of Lamorteau, Mont-Quintin, Harmoncourt, etc.
Carboniferous	... Small globules in a cherty cavernous rock in the Carboniferous Limestone at Visé.

G. A. L.

NORTH SPANISH COAL-FIELDS.

Minas de Santa Ana, en Asturias. By Wenceslao Gonzalez. *Revista Minera y Metalúrgica, Série C., 3a Epoca, Vol. III.*, 1885, *pp.* 11–13, 34–37, 57–58, 65–68.

The Santa Ana mines in the Asturias are situated on both sides of the river Nalon, from Sama de Langreo to near La Pola de Laviana, and comprise a large tract of country to the left of the river. The Coal-Measures occupying this district consist chiefly of sandstones, shales, and siliceous conglomerates, besides coal seams. These beds are much disturbed, sometimes lying in undulating folds, sometimes in angular zig-zags. There is, moreover, an unconformity between that portion which crops out upon the right flank and the strata on the left flank of the Langreo Valley. Three divisions of the Coal-Measures are recognised: a lower one lying immediately upon Carboniferous Limestone beds, a middle one very regularly stratified, and an upper much disturbed and contorted. The seams themselves are very irregular, much given to rapid thinning and thickening, often split up by bands of varying thicknesses, and often re-uniting in short distances.

The concession held by the Santa Ana Company has an area of 3,569·13 hectares (8,923 acres) and is divided into seven sections for convenience in working. These are:—No. 1, on the right bank of the Nalon, between the valley of La Cruz and the Peña Merines, with eleven seams, the average thickness of which is 60 centimetres (23

inches). This section is 474·32 hectares (1,186 acres) in extent. No. 2, of 428·52 hectares (1071·3 acres) comprises the mines of Santa Ana proper, the Juliana, Prisoniera, Lozana, Maxima, Cazadora, Vuelta, Sallosas, Bracilian, Eudosia, Generala, and Florida mines. There are at least twenty seams with an average thickness of 60 to 70 centimetres (23 to 28 inches). No. 3, of 764 hectares (1,910 acres) comprises the Valle de Carroceda, San Andrés de Linares, Ninfa, Abundante, and (in part) Casualidad mines. Here there are forty distinct seams of coal with an average thickness of 70 centimetres (28 inches). No coal has yet been worked in this division. No. 4, of 187·72 hectares (469·3 acres) comprises the Matilde, Pilar, Valentina, Triunfo, Alameda, Florida, and Antepuesta mines. Twenty-two seams are known in this section, 75 centimetres (30 inches) thick on an average, but none has yet been worked. Nos. 5, 6, and 7, together of 1714·57 hectares (4286·4 acres) are not so fully described as the others.

The coal is bituminous and of good quality. Deducting from 25 to 30 per cent. of the amount present in the coal-field for faults and other obstacles, the author estimates that there is enough coal to yield an output of 110,000 tons per annum for an unlimited number of years. Above the valley level alone such an annual output could continue for more than one hundred years. With a pit in the Santa Ana mine, an additional production of 30,000 tons for twenty years would be insured. G. A. L.

BELGIAN MANGANESE DEPOSITS.

Sur la Rhodochrosite de Chevron. *By* G. Dewalque. *Annales de la Société Géologique de Belgique, Vol. XI., Proc. Verb., pp. lxiii.–lxv.*

Trials have been recently made on certain ferro-manganesiferous beds in the neighbourhood of Chevron, on the left bank of the Lienne. These deposits occur in the upper portion of the Salmian (Cambrian) system. In the concession of Bierleux a bed of ore 1·20 metres (3·9 feet) in thickness has been proved, consisting of rhodochrosite and banded quartz or jasper. Picked specimens of the former mineral have yielded 75 and 84 per cent. of carbonate of manganese. Analyses made for commercial purposes of ore from different points in the same concession show the following percentages:—20·738 and 16·905 of iron, 20·482 and 22·876 of manganese, 0·240 and 0·202 of phosphorus, with traces and 0·006 of sulphur. G. A. L.

METAMORPHISM IN COAL.

Sur une transformation remarquable d'une couche de houille. *By* V. Watteyne. *Annales de la Société Géologique de Belgique, Vol. IX., Proc. Verb., pp. xcv.–xcvii.*

A note relating to the Buisson coal-seam worked in the Grand Buisson Colliery at Hornu. This seam, one metre thick (3·3 feet) contains six recognized divisions, of which the fifth (the lowest but one) when in its normal state, consists of 0·04 metre (0·39 inches) of black, compact, earthy, jet-like carbonaceous band, locally known as *gayet*. This band, in a certain part of the colliery, is replaced by pholerite over an area 50 metres in length by 15 metres in breadth. The thickness of the band remains the same, and the rest of the seam is quite unchanged. The pholerite occurs in thin white foliated layers intercalated with black shale. No explanation of the alteration described is attempted. G. A. L.

MINERALS ASSOCIATED WITH DIAMOND IN BRAZIL.

(1) *Noticia relativa a alguns mineraes dos cascalhos diamantiferos contendo acido phosphorico, alumina e outras terras da familia do cerium.* *By* H. Gorceix. *Annaes da Escola de Minas de Ouro Preto, No.* 3, *pp.* 197–202.

(2) *Estudo dos mineraes que acompanhao o diamante na jazida de Salobro, provincia da Bahia, Brazil.* *By* H. Gorceix. *Same publication, pp.* 219–227.

The second of these papers is a detailed account of the minerals found with diamond in the mines of Salobro in the province of Bahia. The washings from this district differ very materially in composition from those of most other diamond regions, more especially by the absence of the oxides of titanium (the *agulhas, cericorias,* and *captivo de chumbo* of the miners), of the hydrated ceriferous phosphate of alumina (*favas*), and of the tourmaline rocks (*feijoes*) so common at Diamantina, Bagagem, etc. The minerals enumerated are:—1.—Quartz. 2.—Flint. It was the presence of fragments of this form of silica which first attracted miners to the Sabrado clays as likely to be diamond-bearing. 3.—Monazite. 4.—Zircon, crystals of which were at first mistaken for diamonds by inexperienced miners. 5.—Almandine garnet. 6.—Disthene, far less abundant than in the Jequitinhonha diamond deposits. 7.—Staurolite, evidently derived from the micaschists of the surrounding country. 8.—Corundum, in very small quantity, but important to note, since in India it is invariably found associated with diamond. 9 and 10.—Magnetite and ilmenite in small grains. 11.—Iron pyrites.

The "*favas*" mentioned above as being common in other Brazilian diamond deposits are fully described in the first paper. G. A. L.

MINERAL IMPORTS AND EXPORTS OF SPAIN.

Importaciones y exportaciones de España en 1883. *Revista Minera y Metalúrgica, Série C., 3a Epoca, Vol. III.,* 1885, *p.* 13.

The following summary is extracted from the *Estadistica comercial de España* for the year 1883, published by the Customs Authorities:—

Imports.

	Tons.		Tons.
Coal	1,124,867	Wrought iron and steel	51,195
Coke	137,807	Tin-plate	3,732
Pitch, asphalt, etc.	20,107	Copper	1,498
Petroleum	40,697	Tin	478
Cast iron	62,079	Zinc	196

Exports.

	Tons.		Tons.
Coal and coke	10,895	Copper ores	564,564
Jet	61	Iron ores	4,225,827
Pitch, etc.	1,280	Manganese ores	4,533
Argentiferous galena	12,598	Cast iron	30,131
Other ores of lead	2,451	Wrought iron	17,035
Blende	15,395	Sheet copper	23,976
Calamine	30,161	Quicksilver	516
Phosphorite	55,772	Lead	128,793
Antimony ores	68	Zinc	1,401

G. A. L.

NICKEL AND COBALT IN NEVADA.

Note on an occurrence of Nickel and Cobalt in Nevada. *By* A. D. HODGES, JUN. *Transactions of the American Institute of Mining Engineers. (Paper read in February,* 1885, *advance sheets),* 2 *pp.*

The mineral described is compact, shining, and black, and appears to be a chrysocolla containing nickel and cobalt. It was found associated with copper silicate and clay in a vein of carbonate of copper worked in 1874, in Ludwig and Carter's mine, near Mason Valley, Esmeralda County, Nevada. With the black mineral occurred some needle-formed crystals also containing cobalt and nickel, but no trace of copper. Analyses by Professor Cornwall and the author, accompany the paper. G. A. L.

POETSCH'S SYSTEM OF PASSING THROUGH WATER-BEARING STRATA.

(1) *Abteufen von Schächten, Bohrlöchern, Strecken und Ausschachtungen aller Art im wasserreichen und schwimmenden Gebirge durch Gefrierenlassen desselben nach der methode von* H. POETSCH *zu Aschersleben. Zeitschrift fur das Berg-, Hütten- und Salinen-wesen, Vol. XXXI., p.* 446.

(2) *Procédé Poetsch pour les travaux à faire dans les terrains aquifères par la congélation. Bulletin de la Société de l'Industrie Minérale, Vol. XIII., p.* 583.

This system consists of transforming, by freezing, quicksands or water-bearing rocks into solid blocks of ice, through which the pits are sunk. The frozen zone must be of such extent that during the sinking there is an artificial wall which resists all external pressure. In every special case careful examination is required, by means of borings, of the thickness of the strata, and it is necessary to calculate the thickness to be given to the wall, in order that it may safely resist, as already mentioned, the pressures produced during the sinking of the pit and the removal of the *débris*. The conversion into ice is effected by means of a series of tubes sunk into the strata to be removed, and a freezing mixture is passed continuously through the pipes until the operation is completed.

The method has been successfully applied to a shaft sinking near Schneidlingen. This shaft, of rectangular form (11 feet by 16½ feet), was sunk through ordinary strata for the first 111 feet, and was only separated from the coal-measures by 18 feet of quicksand full of water. Attempts were made to remove the liquid mass, but they had been suspended after 4 feet had been penetrated. A borehole had been made in the centre of the pit to the first coal-seam, and this allowed the passage of a continued flow of water.

Mr. Poetsch then took the sinking in hand. Twenty-three tubes of 15¾ inches in diameter were driven into the sand and about 2 feet into the seam of lignite situate below it. The lower end of each pipe was carefully closed; pipes of $1\frac{5}{16}$ inch in diameter, open at the lower end, were placed in the tubes. The freezing solution was injected into the smaller pipes, and passed through their lower ends into the large tubes, and ascended into the space between the little internal and the large external tubes. By this means an extreme cold was conveyed to the sand and water in contact with the pipes. The tubes and pipes were connected together and with the freezing machine placed on the surface. The solution was injected by means of a pump into the descending column, and was thence distributed into the twenty-three tubes, whence it reached the rising column and returned to the freezing machine. The freezing machine used was one of Carré's, in which intense cold is produced by the distillation of ammonia.

The lowering of the temperature in the sand was observed by 20 thermometers, placed at intervals over the area of the pit. The average temperatures observed are contained in the following Table. The figures for July 8th give the initial temperatures of the sand and air:—

Date.	Degrees Fahrenheit.		Date.	Degrees Fahrenheit.		Date.	Degrees Fahrenheit.	
	Air at bottom of Pit.	Quick-sand.		Air at bottom of Pit.	Quick-sand.		Air at bottom of Pit.	Quick-sand.
1883.			1883.			1883.		
July 8	54	52	July 16	28	21	July 24	23	4
„ 9	43	44	„ 17	28	20	„ 25	23	2
„ 10	32	36	„ 18	28	15	„ 26	22	2
„ 11	30	26	„ 19	27	15	„ 27	22	2
„ 12	29	26	„ 20	27	11	„ 28	22	0
„ 13	30	24	„ 21	27	9	„ 29	21	0
„ 14	28	22	„ 22	25	7	„ 30	21	0
„ 15	29	22	„ 23	25	6	„ 31	21	0

The low temperature of the air at the bottom of the pit was only found when measured immediately after descending; the temperature rose afterwards, owing to the heat given off by the body of the observer. During the sinking, when many men were employed in the bottom, the thermometer usually stood at 30° or 31°. This degree of cold had no ill effect upon the workmen, but on the contrary stimulated them to greater exertion.

During the sinking, which was made between the tubes, the freezing extended rapidly in all directions from the pit. The bottom of the pit was closed, and the frozen material had a hardness similar to that of post. The material was removed by picks, pointed hammers, and crowbars, without the use of powder; when a yard in depth had been removed it was protected by wood cribbing. The seam of lignite was reached on September 30th, 1883. The seam was found frozen for a depth of one yard below the ends of the tubes, and adhered firmly to the frozen quicksand. This proved that, by this system, in all varieties of strata, irrespective of the inclination and thickness of the sand, a monolithic and solid wall was obtained.

After the pit was sunk down, holes were bored horizontally, to prove the extent of the frozen ground; it was found that there was a circle of ice of about 5 feet diameter around each tube. A wall of more than 3 feet is well qualified to protect the sinking of 3 to 6 feet of the pit, before it becomes necessary to line the sides.

The system appears to have many advantages:—

1.—The pit is sunk with speed and safety when the ground is solid and there is no danger of external pressure.

2.—The absence of risk of loss of capital.

3.—No pumping engine is required.

4.—There is no inconvenience in the sinking, even if the strata are at a high angle, as all the strata are frozen into one solid and coherent mass.

The expense of the system is much less than any other of the methods previously in use, but no details are published of the exact costs.

Mr. Poetsch has sunk three other pits quite as difficult as that near Schneidlingen. In one instance, Centrum Colliery, near Kœnigs-Wusterhausen, 44 yards of sand were traversed with ease in 33 days. At the Emilia Collieries, near Fensterwalde, a pit 9 feet diameter was sunk through a bed of quicksand.

M. W. B.

PNEUMATIC DESPATCH TUBE BETWEEN LONDON AND PARIS.

Transmission Pneumatique entre Paris et Londres. Le Génie Civil, Vol. VI., p. 303.

Mr. Berlier proposes to establish between Paris and London two pneumatic tubes, one there and one back, to be used for the transmission of letters and printed papers, and small parcels, each train carrying 11 lbs.

The tubes would be laid along the railways from Paris to Calais, 184 miles; under the sea from Calais to Dover, 24 miles; and from Dover to London, along the railways, 87 miles; the total length being (say) 300 miles. The greatest depth of the sea between Calais and Dover is 186 feet, the highest point of the railways is 398 feet, and the difference of level between the highest and lowest points of the tube would be 584 feet.

The tubes would be of metal, 1 foot in diameter and about 13 feet long, connected by special india-rubber joints, giving them both flexibility and elasticity, and assuring them from leakage. The carriage would be made of iron wire, lapped round with gauze and asbestos, and would weigh about 11 lbs.

The journey from Paris to London would be made in an hour, and the despatch would be made every ten minutes.

The carriage would form a piston, moved by compressed air at a velocity of 26,400 feet per minute.

The resistances to be overcome would be:—Friction of the carriage and air in the tube, and the elevation of the carriage over the ascents.

The friction of the carriage would be:—22 lbs. × ·7 × 300 miles × 5,280 ÷ 60 minutes = about 13 horse-power.

There are no experiments to show the friction of the air in the tubes, but from trials made at the Mont Cenis Tunnel it may be estimated at not more than 14 horse-power.

Ignoring the advantage of the descents and considering only the ascents, the total of the latter may be taken at 2,240 feet over a length of 164 miles, which would be traversed in 31 minutes. The power required would be:—2,240 feet × 22 lbs. ÷ 31 minutes = 1,590 foot-pounds.

A total power of 28 to 30 horses would be sufficient to drive the carriage and the air through the tube.

The volume of air required would be:—300 miles × 5,280 feet × 1 foot × ·7854 = 1,244,100 cubic feet, about 20,733 cubic feet per minute.

Taking the area of the tube at 113·1 square inches, the velocity at 26,400 feet per minute, and the work at 30 horse-power: then the pressure required to be given to the air may be calculated thus:—30 = (113·1 × 26,400 × P) ÷ 33,000, and P = ·33 lb., and if the coefficient ·50 is obtained P = ·66 lb.

The conclusions are therefore: that forcing 20,733 cubic feet of air per minute under a pressure of ·66 lb. would drive a carriage weighing 22 lbs., whose area is 113·1 square inches.

If a carriage was despatched every ten minutes there would be at all times six carriages in the tube, about 50 miles apart, and the air in this space would form a kind of coupling between them. The air pressure must be increased in proportion to the number of trains, say ·66 × 6 = 3·96 lbs. A normal pressure of 30 lbs. would be ample for the transmission.

It is proposed that the tubes and reservoirs should be capable of resisting a pressure of 200 lbs., which would be created by an auxiliary compressor, and no body could resist this pressure in the tube.

Leakage would be remedied by the erection of intermediate compressors.

The estimated cost is:—

Tubes and laying, &c.	£1,120,000
Main compressors	140,000
Auxiliary compressors	40,000
Contingencies	60,000
	£1,360,000

Assuming the traffic to be:—12 trains each way per hour × 24 hours × 300 working days = 86,400 trains per annum, the working cost is estimated at—

Coal—6,220 tons at 24s.	£7,464
Oils and lighting	536
Interest at 6 per cent. and redemption in 40 years	81,600
Wages, Salaries, &c.	120,000
Contingencies	10,400
	£220,000

If a charge of 2½d. is made per parcel of ½ oz., each train of 11 lbs. should realize £3 13s. 4d., and for 86,400 trains would amount to £306,800 per annum. The annual profit would therefore be £86,800. M. W. B.

UNDERGROUND TEMPERATURE IN JAVA.

Rapport sur le sondage à vapeur pour la recherche d'eau potable à Grissée, île de Java. Partie géologique. Jaarboek van het mijnwezen in Nederlandsch Oost-Indië, 13de Jaargang, 1884, pp. 8–76, with folding map.

A very detailed report on an artesian well bored at Grissée, a town of 25,000 inhabitants on the north coast of Java. The bore reached a depth of 747 metres (2,451 feet) and observations of temperature taken by Mr. J. Ph. Emerling, both during the progress of the boring and afterwards, gave the following results (now published for the first time):—

Depth. Metres.	Feet.		Temperature.
253	(830)	4th March, 1869	30° C. (86° F.)
275	(902)	7th „ „	30° C. (86° F.)
303	(994)	10th „ „	30° C. (86° F.)
310	(1,017)	15th „ „	33° C. (91°·4 F.)
368	(1,207)	20th „ „	36° C. (96°·8 F.)
400	(1,312)	24th „ „	37° C. (98°·6 F.)
410	(1,345)	25th „ „	38° C. (100°·4 F.)
416	(1,365)	taken after the completion of the boring ...	45° C. (113° F.)
422	(1,385)	29th March, 1869	40° C. (104° F.)
472	(1,549)	taken after the completion of the boring ...	48° C. (118°·4 F.)
510	(1,673)	„ „ „ „ ...	50° C. (122° F.)
730	(2,395)	„ „ „ „ ...	58° C. (136°·4 F.)

G. A. L.

ANALYSES OF COALS FROM THE DUTCH EAST INDIES.

Bijdragen uit het scheikundig laboratorium van het hoofdbureau van het Mijnwezen in Nederlandsch-Indië te Batavia. By DR. H. CRETIER. *Jaarboek van het mijnwezen in Nederlandsch Oost-Indië, 13de Jaargang* (1884), *pp.* 311–331.

The following analyses of coals, chiefly from the East Coast of Borneo, are given:—

LOCALITIES.	Carbon.	Hydrogen.	Oxygen.	Sulphur.	Water.	Ash.	Nitrogen.
1.—Pengarong	66·03	5·35	13·31	0·35	4·25	9·36	1·45
2.—Sambalioeng (Goenoeng-Sawar) ...	56·54	3·76	18·05	0·32	17·76	1·51	2·07
3.—Koetei, Batoe-Pangkal Seam, 1·50 m. thick (4·9 feet)	58·30	4·42	17·80	2·95	9·90	6·97	0·34
4.—Do., Batoe-Pangkal Seam, 2 m. thick (6·5 feet)	60·01	4·40	17·19	1·91	13·30	1·46	1·73

	Water.	Coke.	Ash.	Sulphur.	Water taken up in 3 days.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
5.—Laut-Poeloe	4·2	59·5	12·2	—	—
6.—Poeloe-Nangka	2·1	55·35	12·5	1·53	—
7.—Goenoeng-Belaung (G. Tabor) ...	16·7	50·67	0·6	—	10·5
8.—Soengi-Riam (Tanah-Laut) ...	3·4	54·02	3·2	0·80	—
9.—Tengaloeng-Ajam (Koeti), Seam No. 1, 1·15 m. thick (3·8 feet) ..	18·3	53·27	3·0	A mixture of coal from seams 3, 4, 5, 8, 11, 13, and 14 yielded a percentage of 0·41.	7·2
10.—Do., No. 2, 1 m. thick (3·3 feet) ...	21·1	52·87	3·10		11·1
11.—Do., No. 3, 1·35 m. thick (4·5 feet)	17·7	51·95	2·50		8·7
12.—Do., No. 4, 1 m. thick (3·3 feet) ...	20·4	53·42	2·27		9·0
13.—Do., No. 5, 1·40 m. thick (4·6 feet)	20·1	51·25	5·05		8·8
14.—Do., No. 6, 0·80 m. thick (2·6 feet)	20·1	46·62	3·22		9·8
15.—Do., No. 7, 0·30 m. thick (0·9 feet)	14·2	42·22	3·0		6·0
16.—Do., No. 8, 1·80 m. thick (5·9 feet)	18·8	45·67	2·57		7·8
17.—Do., No. 9, 0·45 m. thick (1·5 feet)	17·2	47·50	4·82		6·4
18.—Do., No. 10, 0·65 m. thick (2·1 feet)	17·7	51·27	3·0		7·6
19.—Do., No. 11, 2 m. thick (6·5 feet)...	14·9	47·27	1·92		6·2
20.—Do., No. 12, 0·80 m. thick (2·6 feet)	17·8	45·32	2·37		6·6
21.—Do., No. 13, 1·75 m. thick (5·7 feet)	14·8	45·35	4·70		6·2
22.—Do., No. 14, 1·90 m. thick (6·2 feet)	17·4	45·82	2·77		9·8
23.—Do., No. 15, 1·71 m. thick (5·6 feet)	18·7	47·72	3·15		8·3

G. A. L.

TIN IN DAKOTA.

Tin Ore Veins in the Black Hills of Dakota. By WILLIAM P. BLAKE. *Transactions of the American Institute of Mining Engineers. (Paper read in February,* 1885, *advance sheets)* 5 *pp.*

Tin was discovered in Dakota in 1883, at the Etta Mine, in the centre of the Black Hills, about six miles from Harney Peak, and twenty miles from Rapid City. The rocks are granite, mica and staurolite schists, and arenaceous slates. Sandstones also occur, but no limestone or magnesian rocks. The Etta Mine was established for working mica, which is found in large plates lining the outer portions of a so-called "vein," which appears to be a kind of dyke or boss of very coarse grained granite, having a roughly columnar structure. The mica is succeeded (toward the inner portion of the vein) by

massive quartz, with irregular masses of orthoclase and plagioclase felspar and enormous crystals of spodumene. The whole forms a species of albite greisen, throughout which tinstone (cassiterite) is very evenly disseminated in small partly crystallized grains. Average samples of the rock show about 2½ per cent. of tinstone. Two tons sent to New York yielded between 3 and 4 per cent. of black tin. Besides this disseminated ore some hundred-weights of massive cassiterite have been found outside the greisen-rock.

The minerals associated with the tinstone are albite, quartz, and mica (quartz being the principal veinstone), spodumene (rich in lithia and often enclosing cassiterite), apatite, triphyline, heterosite, leucopyrite or an allied species, tantalite, vitreous copper (rare), and a few others. Topaz is remarkable for its absence, and tourmaline is only represented by a beautiful and rare blue variety—indicolite. The absence of fluorine minerals is the chief point in which the Etta tin deposits differ from those of other countries.

There are now known three well-defined tin regions in the Dakota portion of the Black Hills:—

1.—On the east side of the Harney Range, at the Etta, Ingersoll, Monarch, Peerless, and other claims.

2.—Near the summit at Bismarck's rancho, where the tinstone occurs in narrow quartz veins.

3.—At Hill City, on the western side of the Harney Range, where it occurs both in granite and quartz-veins.

G. A. L.

GOLD IN QUEENSLAND.

Mount Morgan Gold Deposits. By Robert L. Jack. *Report published by the Legislative Assembly of Queensland, November* 21st, 1884. *Folio, 5 pp. Two Maps and three Woodcuts in the text.*

Mount Morgan is about twenty-two miles S.S.W. of Rockhampton, near the head of Dee Creek, a tributary of Dawson River. Gold has quite recently been found here in considerable quantities, and under circumstances of very special geological interest. The auriferous rock is, in fact, to a great extent ironstone, and the rest of the gold is found in siliceous geyserian sinter. The country rock is chiefly quartzite, with other metamorphic deposits and later rhyolites. The gold is clearly shown to be located around a central point, and intimately connected with and due to deposition from thermal springs.

The following results of assays are given:—

1.—Brown hæmatite, 3 oz. 6 dwts. of gold per ton.

2.—Red hæmatite, 6 oz. 16 dwts. of gold per ton.

3.—Aluminous rock from west of dyke. No gold.

4.—Siliceous sinter from among the aluminous rock, 3 oz. 15 dwts. per ton.

5.—Stalactitic brown hæmatite, 6 oz. 11 dwts. per ton.

6.—Siliceous sinter veined with quartz, 4 oz. 5 dwts. per ton.

7.—A mixed mass of ironstone and silica, 5 oz. 3 dwts. per ton.

8.—Ironstained siliceous sinter, 10 oz. 14 dwts. per ton.

The discovery of gold under such circumstances "may lead," the author thinks, "to others of equal importance in a direction where gold has never hitherto been looked for." (Page 5.)

G. A. L.

BRAZILIAN DIAMOND DEPOSITS.

Gisement de Diamants de Grao-Mogor (province de Minas-Geraës) Brésil. By — Gorceix. *Bulletin de la Société Géologique de France, Sér.* 3, *Vol. XII. pp.* 538-545. *Two Figures in text.*

The Grao-Mogor diamond deposits are situated about 300 kilometres (187 miles) north of Diamantina, in the basin of the Jequetinhonha, in the Province of Minas-Geraës. The author points out that, although most of the diamonds found in this district are collected from gravel, filling up narrow fissures and channels, in flexible micaceous quartzite, yet they can be traced to an overlying conglomerate belonging to the same Azoic series as the quartzite. This conglomerate is of considerable extent, but is diamond-bearing in one place only. The diamonds found are, however, quite unrounded, with definite and sharp edges, and are associated with crystals of iron pyrites and martite, likewise free from any traces of attrition. It is inferred from these facts that the diamond (in Brazil at least) must be regarded as having been formed in *situ*, by means of emanations from veins within the Azoic conglomerate described. (See Vol. XXXIII. of these Transactions, Abstracts, p. 29.)

G. A. L.

TIN DEPOSITS OF BRITTANY.

Note sur la constitution des gîtes stannifères de la Villeder (Morbihan). By — Lodin. *Bulletin de la Société Géologique de France, Sér.* 3, *Vol. XII., pp.* 645-666. *Five Figures in text.*

Tinstone has long been known to occur at several localities in the Department of Morbihan; but it is only at La Villeder, in the Commune of Roc-Saint-André, that it is found in workable quantities. Here the stanniferous deposits are quartzose lodes of very variable width, running generally N.N.W. and S.S.E., and hading considerably to the west. These lodes crop out a short distance from the border of a granitic mass, which extends to the west to near Baud and Locminé. The boundary between the granite and the micaschist, which adjoins it, is roughly parallel to the tin lodes, most of which are in the former, though some also traverse the latter rock. The following minerals, mostly well crystallized, are found within the lodes:—quartz, which is the chief veinstone, cassiterite, white mica, beryl, phenakite, topaz, tourmaline, apatite, fluor spar, molybdenite, mispickel, iron pyrites, zinc blende, copper pyrites, galena, and a few secondary minerals, due to the decomposition of some of those already named. Wolfram is absent, and topaz, though present, is extremely rare. Indeed, of the minerals enumerated above, tourmaline and beryl appear to be the only ones which are found constantly associated with the cassiterite, always excepting quartz and mica. Although the lodes in question can be followed lineally for more than four kilometres (2·85 miles), and have by no means all the ordinary characters of stockwerks, yet the author says that in many respects they resemble the tin deposits of the Zinnwald and Michael's Mount rather than the great tin lodes of Cornwall. He concludes that the deposits described yield evidence distinctly unfavourable to the theories of Daubrée and others who would regard them as due to the intervention of fluoride of tin.

G. A. L.

GOLD IN NORWAY.

Das Goldvorkommen in Norwegen By C. Weltz. *Berg- und Hüttenmännische. Zeitung, Vol. XLIV.*, 1885, *pp.* 57, 58.

An account of the occurrence of gold off the West Coast of Norway, in the Island of Bömmelöen, about half-way between Bergen and Stavanger. That gold was to be found in small quantities in that locality has been long known, but only recently has much attention been drawn to it, an English Company having begun to mine for it, and a kind of gold fever (unwarranted by the facts, as the author appears to think) having, in consequence, spread over the district. The rocks of the island are of igneous origin, gabbro, granite, and quartz-porphyry forming the more massive portions, and greenstone dykes and quartz veins piercing through them. So far, what gold has been found is associated with the gabbro, and, although it is hoped that the quartz veins may yield gold in sufficient commercial quantities, they have not yet proved to contain more than traces of the precious metal. These veins or "reefs," however, are connected with a chloritic slate which is to a certain extent auriferous. G. A. L.

EXPERIMENTS ON THE COMPRESSION OF FOSSIL FUELS.

Note sur la compression de quelques combustibles fossiles. By R. Zeiller. *Bulletin Société de la Géologique de France, Sér.* 3, *Vol. XII., pp.* 680–685.

Some time since Mr. Spring announced that by subjecting peat to a pressure of 6,000 atmospheres he had converted it into a black, bright, hard substance, having all the physical aspect of coal. The writer of the present paper, in order to test these results, devised an apparatus consisting of a steel mould with a well-fitted piston in connection with a machine for testing metals, and capable of exerting very great pressure. The substances experimented on were:—(1) paper-coal, from the Tovarkova mine in Central Russia, which may be regarded as ulmic acid unaltered since its deposition; (2) lignitic coal from the same locality; and (3) peat. These were placed in the steel mould, and the piston was pressed upon them with pressures varying from 2,000 to 10,000 kilogrammes per square centimetre (9,765·22 lbs. to 48,826·12 lbs. per square foot). In no case did conversion into coal take place, either as to physical condition or chemical composition. The latter point is well brought out by careful analyses made of each specimen before and after compression, which conclusively prove that, practically, no alteration has taken place. G. A. L.

THE CARATAL GOLD-FIELDS, VENEZUELA.

Gisements aurifères du district "le Caratal" (Guyane Vénézuélienne). By Ch. Monchot. *Le Génie Civil, Vol. VI., pp.* 341–346, *and pp.* 357–361. *With two Plans and two Views.*

The annual production in Venezuela of 11,000 lbs. entitles it to take the fifth place as a gold producing country. The whole of its gold produce is derived from the Caratal District, which is of small extent, so far as its present known gold-fields are concerned.

The discovery of gold in Caratal is comparatively recent, and the region is scarcely explored. However, its enormous production, and especially the magnificent returns of the Callao mine, has attracted universal attention.

The Caratal gold mining district is situated in Venezuela, on the right bank of the river Oronoco, about 35 miles south from that river, and 150 miles from the Atlantic Ocean. It took its name from Caratal, now called Nueva Providencia, which, although hardly 30 years old, is the oldest town in the country.

The district is readily reached from Europe by mail steamers to Port of Spain, in about 20 days. Steamers run from Port of Spain to Bolivar, on the river Oronoco, passing Las Tablas, which is the landing place for Caratal; but the formalities of the customs necessitate the journey to Bolivar for their performance. The same regulations apply to all merchandise. There are two ways to the mines from Bolivar—one over land, the other down the river to Las Tablas, and thence over land. The first is little used, except for the transport of machinery. It takes travellers six or seven days, and goods fifteen or twenty days in good weather. The second takes from eight to nine hours to descend the river to Las Tablas, and about four days on horseback, thence to Nueva Providencia. It is intended to make a railway from the mines to Viega, on the Oronoco.

Very little is known of the geological structure of the district, there being few faults to facilitate the study of the super-position of the strata. Most of the mines are of little depth. Between the Oronoco and the Yuruari the surface is generally granite and gneiss, whose decomposed material forms the sands of the savannahs, but nearer to Caratal they are displaced by diorite.

Diorite.—This forms the bulk of the rock of the district. It is usually compact and homogeneous. It forms the casing of the veins, and then it may be schistoze, somewhat contorted and mixed with quartz. It is sometimes mineralized by contact of the veins, and contains notable quantities of auriferous pyrites, and sometimes visible gold. It is sometimes hard in contact with the veins, and is called *piedra azul* (blue stone) by the miners.

Cascajo.—A tender stone, argillaceous, and of a red or yellow colour, is found above the diorite, and known as *cascajo*. This rock is easily worked by the pick, but increases in hardness with depth, and passes insensibly into diorite, without any distinct line of demarcation.

Alluvium.—At many points, and notably at Nueva Providencia, the cascajo is covered by alluvium, called *greda*. This consists of broken, worn quartz, and decomposed diorite, enclosed in a clay, of colours varying with the locality. This is covered by more recent deposits of complex material, usually argillaceous, and more or less coloured red by oxide of iron. These alluvia are auriferous, most especially the greda, which is very rich. The gold is found in grains and float, and sometimes in small nuggets. The first workings for gold were made in this deposit.

Moco de hierro.—Different rocks are found in several places, such as hornstone forming dykes, also a highly ferruginous conglomerate, called *moco de hierro*. It is said to be auriferous, but has not been worked.

Veins.—The Caratal district is furrowed with many auriferous quartz veins. They appear to lie in three directions, east to west, such as those of Panama, Chile, Potosi, and Eureka; north-east to south-west, as at Caratal and Tigre; others range from north to south, such as the famed Callao vein, and those of Independencia and Santa Rosa. The inclination of the veins varies between 30° and 70°.

Matrix.—All the veins are similar; the surrounding rocks are always piedra azul; the matrix of the vein is usually white quartz, like mother-of-pearl, coloured with streaks of oxides of iron and manganese. The veins pass through the cascajo, but the quartz is somewhat decomposed like the casing rock.

Thickness.—The thickness is very irregular. At Callao the thickness varies from 1 foot to 8 feet, and is about 4 feet on the average. At the Chile mine the vein is

sometimes only 9 inches thick; in the part of the same vein worked by the Potosi Company, it is found to be 16 feet thick. The most usual thickness is about 3 feet.

Value.—The richest veins, judging by the results obtained at the Callao mines, are those running from north to south. At Callao, in 1871, the produce was 6·25 ounces per ton, worth £21 12s. 9d.; in 1872, 3·83 ounces, or £12 8s.; it then rose until in 1874 it reached 4·33 ounces, or £15 12s. In 1875 it fell to 2·64 ounces, or £10 5s; thence it improved, becoming in 1878, 5·13 ounces, or £20 4s. per ton; and in 1881 it again fell to 2·90 ounces, or £11 3s. per ton, and has since risen to 8 ounces per ton. Callao, which is the deepest mine, has only attained a depth of 200 yards. None of the veins lying in other directions possess the richness of the Callao. Of those bearing from east to west the Panama yields about 2 ounces per ton, the Chile has rarely exceeded 2 ounces, and has for some time only yielded ¾ of an ounce, worth about £2 15s. per ton. The Peru, belonging to the New Potosi Company, has yielded 2 ounces for some months, but has now fallen under 1 ounce. Of those bearing from north-east to south-west, the Caratal, from 1873 to 1880, treated 26,631 tons of quartz, which produced 34,420 ounces of gold, or 1·29 ounces per ton.

Distribution of the gold in the veins.—The gold is usually found native in the quartz in grains invisible to the eye, and even to the microscope. But in several veins, notably the Callao, nearly all the quartz contains visible gold. Gold also exists in the arsenical pyrites which is found in the quartz. At the Tigre mines the pyrites forms 3 to 4 per cent. of the rock.

Mode of working.—The vein is usually cut by a vertical shaft, and further depth attained by following it downwards. The system of working is very simple—pillars and galleries. Timber is an expensive item, especially when mining in the cascajo. Steam is used for draining the mines owing to the absence of water-power. For some years the Callao mine spent £100,000 for wood fuel, and £20,000 for mining timber. Bricks are made in the neighbourhood, cement comes from Europe, and lime from the Antilles.

Dressing.—The mineral on leaving the mine is crushed by stone breakers to the size of a fist, and the crushing is completed by stamps. The pulverization is made in the presence of water, which carries the powder to the copper amalgamating tables. Amalgamation begins at the stamps by the addition of small quantities of mercury at regular intervals. About 70 per cent. of the gold is retained, the loss of 30 per cent. being due to the fineness of the gold, and to the gold in the pyrites.

Cost of working.—The cost of working is high, owing to the unwholesome climate, the excessive cost of carriage, high customs duties, high wages; all stores, fuel especially, are in ratio with the cost of carriage and wages. The cost per ton of mineral treated is more than £6 at Callao, and about £5 at Chile.

Mining Companies.—El Callao was formed in January, 1870, with a capital of £12,880. This was found insufficient, and was, in 1873, increased to £51,520. From 1875 to the end of 1883 the dividends have amounted to £817,880, the gross yield being £2,385,920. In 1884, the dividend was nearly £400,000. Several companies, such as the Nouveau-Monde, Chile and Potosi having exhausted their original capital, have been revived with additional new capital, and are still working. Others, such as the Hansa, Tigre, and Panama have suspended operations for want of funds. Others have wasted their capital in stamps, etc., before they found their vein. There are other companies working in the district, viz., Caratal, Eureka, Union, Callao bis, West Callao, New Callao, Central Callao, etc., but their workings are not extensive. M. W. B.

COMPRESSION VENTILATION OF A MINE BY MEANS OF A GUIBAL FAN PLACED UNDERGROUND.

Die unterirdische Guibal-Ventilatoranlage im Alexander-Schacht der v. Arnim'schen Steinkohlenwerke zu Planitz bei Zwickau, nebst einigen Bemerkungen über die Anwendung der Pulsionmethode in der Grubenventilation. By B. Otto. *Zeitschrift für das Berg- Hütten- und Salinen-Wesen, Vol. XXXII., p.* 159.

Notwithstanding that Von Arnim's colliery was ventilated by a Guibal fan, supplying a volume of nearly 106 cubic feet (3 cubic metres) per minute per man employed in the mine, there was some difficulty in preventing the carbonic acid from the old workings, although carefully closed up, from fouling the air of certain districts of the mine.

A ventilator has been placed near the bottom of the Alexander Shaft, at a depth of 626 feet (191 metres), 17 feet (5·13 metres) above the hanging on, and 26 feet (8 metres) above the bottom of the sump, which was considered to be a safe position, as there were two pumping engines of 250 horse-power. This Guibal fan compresses the air instead of exhausting in the usual way. Under ordinary conditions it produces a volume of 24,720 cubic feet (700 cubic metres) of air per minute, and would produce, in case of emergency, 56,500 cubic feet (1,600 cubic metres) per minute. The workings ventilated consist of 8,200 feet (2,500 metres) of galleries, varying from 21·5 to 65 square feet (2 to 6 square metres) in area. The fan has eight vanes, is 22 feet 11 inches (7 metres) in diameter, and 5 feet 7 inches (1·7 metres) wide. The fan chamber is made in the thick and lower Planitz seam and superincumbent shales. The side walls, etc., are built of hard bricks, with a smooth facing of cement. The air is admitted by circular inlets on each side of the fan, and is expelled into the delivery drift of rectangular section. The discharge from the fan is regulated by a sliding shutter provided for the purpose.

The engine is placed adjacent to the fan; it is direct acting, with variable expansion gear and condenser. The piston has a diameter of 20·47 inches (·52 metres), and a stroke of 31·49 inches (·8 metres). The normal speed is 45 revolutions per minute, which can be increased to 100 revolutions in emergencies. The fan has run almost continually since December, 1881. The following experiments were made in 1883:—

	No. 1.	No. 2.
Volume of air per minute in cubic feet ...	26,107	25,565
„ „ in cubic metres ...	739·23	723·87
Water gauge, in inches	·7874	·7677
„ in millimetres	20	19·5

This gives a mean volume of 25,836 cubic feet (731·55 cubic metres) for 45 revolutions of the fan, and at 100 revolutions the volume would be about 57,400 cubic feet per minute.

The adoption of compression ventilation has reduced the proportion of carbonic acid gas from 11·9 parts per 1,000, when the exhausting fan was used, to 8·9, that is an improvement of 3 per 1,000. In the working places the effects are more apparent. Thus, in one place there was of carbonic acid gas, with the ventilator standing, 27·9 per 1,000, and when the fan was running only ·8 per 1,000.

M. W. B.

SAFETY LAMPS.

Über die in neuerer Zeit in dem Ostrau-Karwiner Revier verwendeten Sicherheitslampen. By Joh. Meyer. *Glückauf. Berg- und Hüttenmännische Zeitung, Nos.* 25, 26, 1885.

	Muesseler Lamp.	Benit Lamp.	Wolf's Benzin Lamp.	Marsaut Lamp.
Weight of lamp bottom, in pounds	·770	1·080	·924	·880
Do. cage, &c. do.	1·606	1·699	1·342	2·002
Do. empty lamp do.	2·376	2·779	2·266	2·882
Do. oil do.	·363	·290	·187	·308
Do. lamp and oil do.	2·739	3·069	2·453	3·190
Time of burning, in hours	30	24	18	24
Consumption of oil per hour, for full burning light, in pounds	·0114	·0121	·0123	·0127

M. W. B.

PRICES OF COAL AND COKE AT ST. ETIENNE.

Prix-Courants des Charbons et Cokes à St. Etienne. Bulletin de la Société de l'Industrie Minérale, Sér 2, *Tome XIII.*, 1884, *pp.* 251, 665, 891.

Kind of Coal.	Price per Ton of 2,204 lbs.		
	1st July, 1884.	1st Jan., 1885.	15th March, 1885.
	s. s.	s. s.	s. s.
Large hard hand picked, first quality	28·8 to —	28·8 to —	28·8 to —
Large tender hand picked, second quality ...	21·6 „ 24·0	22·4 „ 24·0	23·2 „ 24·0
„ „ ordinary	20·8 „ —	21·6 „ —	20·8 „ —
Screened, first quality	18·4 „ 21·6	20·0 „ 21·6	19·2 „ 20·8
„ second quality	15·2 „ 17·6	16·8 „ 19·2	16·0 „ 17·6
Nuts, washed	13·6 „ 16·0	13·6 „ 16·0	13·6 „ 16·0
„ unwashed	11·2 „ 12·8	11·2 „ 12·8	10·4 „ 12·8
Gas, first quality	14·4 „ 16·0	14·4 „ 16·0	14·4 „ 16·0
„ second quality	— „ 12·8	— „ 12·8	— „ 12·8
Smith's small, first quality	17·6 „ 20·0	17·6 „ 20·0	17·6 „ 20·0
„ second quality	16·0 „ 16·8	16·0 „ 16·8	16·0 „ 16·8
„ washed	14·4 „ 15·2	14·4 „ 15·2	14·4 „ 15·2
House, first quality	12·0 „ 13·6	11·6 „ 13·6	11·2 „ 12·8
„ second quality	11·2 „ —	11·2 „ —	10·4 „ —
Small, for large forgings	10·4 „ 11·2	10·0 „ 11·2	10·0 „ 10·4
„ for lime burning	7·2 „ 8·0	6·4 „ 8·0	6·4 „ 8·0
„ average quality	7·2 „ 8·8	7·2 „ 8·0	7·2 „ 8·0
Washed coke, first quality	28·0 „ 30·4	25·6 „ 27·2	24·0 „ 27·2
„ second quality	20·8 „ 23·2	20·8 „ 22·4	20·8 „ 22·4
Coke for blast furnaces	— „ 18·4	— „ 18·4	— „ 18·4
Small coke of good quality for house	16·0 „ 18·4	16·0 „ 18·4	16·0 „ 18·4
Small coke	8·0 „ 12·0	8·0 „ 12·0	8·0 „ 12·0
Patent fuel (Agglomérés)	— „ —	15·2 „ 18·4	14·4 „ 17·6

J. H. M.

MINING IN THE BUKOWINA.

Der Bergbau in der Bukowina. By W. Kellner. *Berg- und Huettenmænnische Zeitung, Vol. XLIII., pp.* 377–379.

The Bukowina occupies 10,451 square kilometres (6,493 square miles) of the north-easternmost cisleithan portion of the Austro-Hungarian Monarchy, and contains 522,200 inhabitants. It is a mountainous district which, for political purposes, is divided into seven departments, viz., Czernowitz Stadt, Czernowitz Land Kimpolung, Kotzmann, Radantz, Sereth, Storozinetz, Sucsawa, and Wiznitz. For mining purposes, however, the author adopts the following seventeen divisions, based upon geological characters:—

1.—The *Dniester table-land:* comprising a layer of gypsum, and numerous underground streams.
2.—The *Valley of the Pruth:* an alluvial and drift (Loess) district, with workable peat-beds. Sandstone also occurs.
3.—The *immediate neighbourhood of the Capital:* with clay, Loess, and sandstone.
4.—The *Watershed between the Pruth and Sereth:* same as No. 3.
5.—The *Lower Czeremosz Valley:* with alluvium and blue clay.
6.—The *table-land of the Sereth:* same as No. 5.
7.—The *Upper Valleys of the Sereth and Sucsawa:* with a subsoil of blue clay, drift, and mountain *débris.*
8.—The Upper *Czeremosz Valley:* with Carpathian sandstone beneath the alluvium.
9.—The *North-eastern Mountain-foot:* same as No. 8.
10.—The *junction of the two Sereths:* same as No. 8.
11.—The *Lower Sereth district:* same as No. 8.
12.—The *Watershed between the Sereth and the Sucsawa:* with blue clay and Loess.
13.—The *Sucsawa Valley:* with alluvium and sandstone.
14.—The neighbourhood of the *town of Sucsawa:* with alluvium, sand, sandstone, clay, and Loess.
15.—The *Upper Solonetz Valley:* same as No. 14.
16.—The *Moldawa and Sucha Valleys:* with Carpathian sandstone.
17.—The *Southern Mountains:* themselves formed of Micaschist and limestone, with blue clays at their base.

Mining began in 1784, when iron mines were opened in the Kimpolung district. In 1797 argentiferous galena was discovered by Manz, at Kirlibaba, where, in 1800, magnetite and brown hæmatite were also found, and a large mining centre was established. At Pozoritta, not far off, copper ore was discovered in 1821, and worked in connexion with the foregoing. Some gold-washing was afterwards carried on on the banks of the Bystritza. Salt and petroleum are also worked in the region.

G. A. L.

SALT IN THE SOUDAN.

Die Salzkammer des Súdân. By W. Kellner. *Berg- und Huettenmænnische Zeitung, Vol. XLIII., p.* 408.

A short account of the salt mines and commerce of the Soudan. From Kalâla 70,000 camel-loads of salt are exported yearly. The best quality is that found at Bilmâ, where the salt mines are from 10 to 20 metres (32·8 to 65·6 feet) long, and from 6 to 10 metres (19·5 to 32·8 feet) in width, and the heaps of earth surrounding them are from 8 to 10 metres (25·8 to 32·8 feet) high. Members of the Tüârik tribes carry the salt to the equator and beyond, and sell it at a profit of three hundred per cent.

G. A. L.

QUICKSILVER IN ITALY.

Ueber die Quecksilbererze in Toscana und über den darauf betriebenen Bergbau in alter und neuer Zeit. By Theodor Haupt. *Berg- und Huettenmænnische Zeitung. Vol. XLIII., pp.* 423–425, 435–438, 448, 449, 472–475, 481–484, 495–499.

Cinnabar occurs in Tuscany either in true veins or as bedded deposits, having a constant tendency to shift their horizons. It is mostly crystallized, very rarely earthy, or amorphous. It is more commonly associated with clay, more seldom with calcite, quartz, iron pyrites, iron glance, magnetite, and black manganese ore. The quicksilver region lies between the Apuan Alps and the Monte Amiata highlands, and traverses the lead and silver ore zone in the north, the copper ore zone in the centre, and copper and non-argentiferous lead ore zone in the south. Within these limits mercurial ores have been found at the following places (proceeding from north to south):—Levigliani, Ripa, Jano, Astrone, Abbadia San Salvatore, Cana, Pian Castagnajo, Castellazara, Zolforata, Selvena, the neighbourhood of Grosseto, San Martino, and Capalbio. Particulars are given as to mode of occurrence, discovery, workings, etc., in all the above localities. G. A. L.

THE YAULI MINING DISTRICT IN PERU.

Ueber den Minendistrict Yauli in Peru. By Dr. Pflücker y Rio. *Berg- und Huettenmænnische Zeitung, Vol. XLIII., pp.* 341–343, 353–355, 365, 366, 405–408, 425–427. *(Translated from the "Anales de Construcciones civiles y de Minas de Peru," Vol. III.*

Yauli is a village of about 600 inhabitants, situated in the Cordillera, near to where the latter reaches an elevation of nearly 5,000 metres (16,404 feet) at the Piedra Parada Pass, and is about 160 kilometres (99 miles) from Lima. The mining district named after this spot has in turns been regarded as belonging to the provinces of Huancayo, Jauja, and Tarma. Since 1877 it has formed part of the last-named. The lofty plateau on which Yauli stands is chiefly formed of rocks of Cretaceous age, through which trachytic and dioritic intrusions occur, running parallel to the Andean strike. The sedimentary deposits are much disturbed and highly altered, and within them are found the rich ore-bearing veins of the region. The Eastern Cordillera is older, and consists of micaceous and talcose schists, clay-slate, and granite. Throughout these rocks quartz reefs are abundant. A dark grey limestone, supposed to be of Carboniferous age, is also mentioned as occurring in this more ancient tract. The mineral riches of the district comprise ores of silver, lead, copper, antimony, quicksilver, and iron, with some coal. Andaichagua, to the east of Yauli, is the silver region *par excellence*, and here are many ancient mines, as well as new ones, all of which are enumerated and briefly described by Dr. Pflücker y Rio. The principal copper mine is that of San Francisco, near Morococha. Only one quicksilver mine is mentioned—that of Pucayacu—where cinnabar is found impregnating a yellowish-white sandstone. At Tuctu, where some amalgamation works are established, there is a pyrites mine. The ore is massive, mixed only with a little milky quartz, and occurs in a layer 4 metres (13·12 feet) thick. It contains some silver and gold. The coal mines, which are situated at a considerable distance from the village of Yauli, are those of Santo Domingo, Sorao, and Chuichu. The seams, though few in number, are of workable thickness (from 0·5 to 2·5 metres = 1·64 to 8·2 feet), and are said to be of fair quality.

The amount of silver produced in the Yauli district in 1880 was 4,000 kilogrammes (3·92 tons). The amount of ore was 2,300,000 kilogrammes (2,254 tons). G. A. L.

MINING PRODUCE OF THE DISTRICT OF DORTMUND (HANOVER, WESTPHALIA, AND RHENISH PRUSSIA) IN 1884.

Produktions-Übersicht der im Oberbergamtsbezirk Dortmund im Jahre 1883, *in Betrieb gewesenen Bergwerke und Salinen. Glückauf. Berg- und Hüttenmännische Zeitung, No.* 24, 1885.

A.—Coal Mines.

District.	No. of Collieries.	Produce in Tons.	Persons Employed.
1.—Osnabruck	9 ...	114,669 ...	879
2.—Hamm	4 ...	503,501 ...	1,991
3.—Dortmund, East	14 ...	1,824,787 ...	7,572
4.— Do. West	16 ...	1,970,402 ...	8,252
5.—Witten	9 ...	1,612,668 ...	59,59
6.—Sprockhövel	27 ...	484,750 ...	2,072
7.—Dahlhausen	16 ...	1,977,810 ...	7,528
8.—Bochum	11 ...	2,897,707 ...	10,142
9.—Herne	7 ...	2,351,005 ...	7,771
10.—Recklinghausen	10 ...	1,677,091 ...	5,518
11.—Gelsenkirchen	9 ...	2,967,601 ...	9,880
12.—Essen	8 ...	3,025,956 ...	8,867
13.—Frohnhausen	11 ...	2.550,456 ...	8,389
14.—Oberhausen	15 ...	2,889,026 ...	10,199
15.—Altendorf	19 ...	1,089,080 ...	3,821
16.—Werden	10 ...	261,240 ...	1,045
Private mines in 1884 ...	195 ...	28,197,749 ...	99,885
Government mines in 1884	2 ...	202,837 ...	1,128
Grand total of 1884	197 ...	28,400,586 ...	101,013
Do. 1883	201 ...	27,863,025 ...	97,922

B.—Iron-ore Mines.

District.	No. of Mines.	Produce in Tons.	Persons Employed.
1.—Osnabruck	8 ...	234,792 ...	900
2.—Hamm	1 ...	4,085 ...	20
3.—Dortmund, East	3 ...	59,135 ...	217
6.—Spockhövel	4 ...	58,448 ...	231
7.—Dahlhausen	1 ...	180,925 ...	595
15.—Altendorf	2 ...	9,465 ...	47
16.—Werden	2 ...	6,421 ...	27
Total of 1884	21 ...	553,271 ...	2,037
Do. 1883	21 ...	476,100 ...	1,925

C.—Zinc-ore Mines.

District.	No. of Mines.	Produce in Tons.	Persons Employed.
5.—Witten	1 ...	20,335 ...	565
6.—Sprockhövel	2 ...	1,746 ...	25
16.—Werden	2 ...	9,793 ...	482
Total of 1884	5 ...	31,874 ...	1.072
Do. 1883	8 ...	31,587 ...	1,108

D.—Lead-ore Mines.

District.	No. of Mines.	Produce in Tons.	Persons Employed.
1.—Osnabruck	1 ...	60 ...	6
5.—Witten	2 ...	99 ...	10
16.—Werden	3 ...	642 ...	91
Total of 1884	6 ...	801 ...	107
Do. 1883	7 ...	1,611 ...	333

E.—Copperas Mines.

District.	No. of Mines.	Produce in Tons.	Persons Employed.
1.—Osnabruck	1 ...	388 ...	...
6.—Sprockhövel	1 ...	31,225 ...	188
16.—Werden	1 ...	140 ...	2
Total in 1884	3 ...	31,753 ...	190
Do. 1883	3 ...	28,211 ...	174

F.—Salt Works.

District.	No. of Works.	Produce in Tons.	Persons Employed.
1.—Osnabruck	2 ...	1,132 ...	40
2.—Hamm	3 ...	16,514 ...	169
Private works in 1884 ...	5 ...	17,646 ...	209
Government Works in 1884	1 ...	1,914 ...	29
Grand total in 1884 ...	6 ...	19.560 ...	238
Do. 1883 ...	6 ...	18,159 ...	225

M. W. B.

FLAT MANILLA HEMP WINDING ROPES.

Nouvelle Formule donnant le profil rationnel des cables plats en aloès. By CHARLES VERTONGEN. *Bulletin de la Société de l'Industrie Minérale, Sér 2, Tome XIII.*, 1884, *pp.* 413–433.

This paper is devoted to a comparison between two kinds of flat Manilla hemp winding rope. The merits of a new kind, which is rapidly gaining favour in France and Belgium, are advocated above those of the ordinary pattern. In both cases the rope consists of two portions—the lower or working portion, of length equal to the depth of the mine, is of continually increasing section, proceeding upwards to parts where the strain is greater; the upper portion, a reserve length of 300 yards or more, is of uniform section equal to that of the lower at its highest point. No account is taken of this, except when considering the total weight of the rope and the mean thickness. Each of these two quantities should be a minimum, for on them depends the moment of vertical resistance about the centre of the drum. Hitherto the lower part has generally been constructed so that the tension per unit section is constant at all depths Given the following quantities (a foot and lb. being the units employed)—

x_P = width of rope at any pt. P,
a = constant ratio of thickness to width,
L_1, S_1, P_1 = length, section in direction of thickness, and weight of working portion,
L_2, S_2, P_2 = same quantities for reserve portion;

so that mean thickness $= \dfrac{S_1 + S_2}{L_1 + L_2}$.

δ = weight of cubic ft. of rope,
t = maximum tension per sq. ft. that cable can sustain,
Q = load,

it is then possible to calculate the following formulæ—

$$x_A = \sqrt{\frac{Q}{at}}; \qquad x_B = \sqrt{\frac{Q}{at}}\, e^{\frac{\delta}{2t} L_1};$$

where A and B are the lowest and highest points of the working portion of the rope—

$$S_1 = \frac{2}{\delta}\sqrt{Qat}\left(e^{\frac{\delta L_1}{2t}} - 1\right); \qquad S_2 = \sqrt{\frac{Qa}{t}}\, e^{\frac{\delta}{2t} L_1} . L_2;$$

$$P_1 = Q\left(e^{\frac{\delta}{t} L_1} - 1\right); \qquad P_2 = \frac{L_2 \delta Q}{t}\, e^{\frac{\delta}{t} L_1}.$$

Now, if a different law of construction be followed—viz., that the tension per unit section diminish with the height, so that the tension per unit section at B exceeds that at A by the weight of b lbs.—the above formulæ become—

$$x_A = \sqrt{\frac{Q}{a(t+b)}};$$

$$x_B = \sqrt{\frac{Q}{at}}\left(1 + \frac{b}{t}\right)^{\frac{L_1 \delta}{2b}};$$

$$S_1 = \frac{2L_1}{L_1\delta - b}\sqrt{\frac{}{Qa(t+b)}}\left\{\left(\frac{1}{1+\frac{b}{t}}\right)^{\frac{1}{2}}\left(1 + \frac{b}{t}\right)^{\frac{L_1\delta}{2b}} - 1\right\};$$

$$S_2 = L_2 \sqrt{\frac{Qa}{t}} \left(1 + \frac{b}{t}\right)^{\frac{L_1 \delta}{2b}};$$

$$P_1 = Q \left\{ \left(1 + \frac{b}{t}\right)^{\frac{L_1 \delta}{b}} - 1 \right\};$$

$$P_2 = \frac{Q}{t} \left(1 + \frac{b}{t}\right)^{\frac{L_1 \delta}{b}} L_2 \delta.$$

For ordinary depths b may be taken as 22 tons per square foot, but should be greater for greater depths. A single example will suffice for a comparison. A load of 10 tons is raised from a depth of 250 fathoms; here

$Q = 22 \times 112 \times 20$ lbs.,
$L_1 = 1{,}500$ ft.,
$L_2 = 300$ ft.
Let $a = \frac{1}{6}$ (the usual ratio for ropes of 8 strands),
$\delta = \frac{3}{4}$ tons $= 2{,}180$ lbs.,
$t = 66$ tons per sq. ft.
$b = 22$ tons per sq. ft.,

the following results are obtained, obviously in favour of the new:—

	Old Kind.	New Kind.	Unit.
x_A	·95	·825	feet.
x_B	1·33	1·235	,,
S_1	319	251	sq. ft.
S_2	72	62	,,
P_1	22,690	15,680	lbs.
P_2	5,400	4,636	,,

Additional advantages are claimed for the new kind, all of which are of great importance in consideration of the fact that the rope is especially liable to wear away at the junction of the working and reserve portions—*i.e.*, at the point B. The jerk at the lift is diminished by the less weight, and on account of the smaller mean thickness the radius of the drum can be increased without unduly increasing the moment of vertical resistance about the centre; so that the thicker parts of the rope do not suffer so much in coiling, while the elongation of the upper part of the working portion (in the neighbourhood of B) is reduced from 12 to 4½ per cent. (to quote one particular experimental result obtained after three weeks' work), and hence the strength of these parts is less affected by the diminished density. Moreover, the equilibrium at all stages of the ascent is considerably improved, and the machinery, in consequence, subject to less strain; so that machinery of less power may be used, and the work performed in a more efficient manner. Lastly, a considerable saving is effected in the cost of the material.

W. F. P.

THE IRON MOUNTAIN OF DURANGO, IN MEXICO.

Der Eisenberg Cerro Mercado bei Durango, Mexico. By L. Kleinschmidt. *Berg- und Huettenmænnische Zeitung, Vol. XLIII., pp.* 533–535, *with two figures in Plate II.*

This isolated hill is probably the largest mass of iron ore in the world. According to Weidner its length from east to west is 1,750 varas (6,311·7 feet), it is 400 varas in breadth (1,442·68 feet), and it rises 234 varas (863·96 feet) above the Plazuela de San Antonio in Durango, from which it is two kilometres (1·24 miles) distant. The Cerro Mercado, as the iron mountain is called, is divided into two parts by a broad zone of porphyry, and the whole is surrounded by hornblendic and other eruptive rocks; those to the north containing much silica, in the form of hornstone, jasper, etc. The iron ore is very frequently crystallized, and though generally clearly magnetic, is yet not so strongly so as that of Shephard Mountain, near Pilot Knob, in Missouri. G. A. L.

COAL IN HUNGARY.

(1) *Die Steinkohlenformation und der Kohlenbergbau von Szekul in Ungarn.* By X. *Berg- und Huettenmænnische Zeitung, Vol. XLIII., pp.* 536–538. *One figure in Plate II.*

The true Coal-Measures crop out to the day in South Hungary, in Krasso-Szörény County, on the north-western and north-eastern border of the so-called Banat basin. Two coal-fields are recognised in this region—that of Klokodics-Lupak, and that of Szekul, near Reschitza. The latter forms the subject of this paper. It extends from the Berzava Valley to that of the Great Reoalb, running nearly parallel to the Szekul Valley. The Coal-Measures here lie unconformably upon micaschist and gneiss, and consist of conglomerates (at the base), sandstones, shales, and intercalated coal-seams with a high westerly dip. Above are rocks of Permian age, showing no trace of unconformity, and containing plants very similar to those which are found in the coal-bearing series. Of the latter a list is given. The seams and the beds between them both vary considerably in thickness. The thickest mentioned is 2·5 metres (8·2 feet), and the thinnest 1 metre (3·28 feet). Four principal seams are described, and analyses showing their composition are given. According to these the percentage of carbon varies from 36·08 to 72·51, of hydrogen from 2·96 to 4·96, of nitrogen from 1·57 to 1·64, of oxygen from 9·22 to 15·37, of sulphur from 9·52 to 1·48, of ash from 6·02 to 45·64, and of water from 0·49 to 0·94. Beds of clay ironstone also occur, and seem to correspond in a marked manner with the coal-seams with which they are associated as to thinning and thickening.

Coal was first worked in this coal-field at the end of the last century.

(2) *Die liasischen Kohlenlager und das Kohlenwerk von Domán bei Reschitza (Ungarn).* By X. *Same publication, pp.* 545–548. *One figure in Plate II.*

Immediately overlying the Permian rocks of the Banat is a thick series of Liassic age, which, in the neighbourhood of Domán, a village near Reschitza, in South Hungary, attains a great thickness, and is coal-bearing. This formation consists chiefly of sandstone, comprising two workable seams of coal. Above the sandstone is shale. The seams mentioned are 1·9 and 1·3 metres thick respectively (6·23 and 4·26 feet), and are much disturbed and faulted. Notwithstanding this they have been worked since 1819, and yield merchantable coal and coke. Full analyses are given, and the mode of working is described. At the present time the coal-mines employ 638 men.

G. A. L.

FELSPAR COAL WASHERS.

Lavoirs au Felspath. Atelier de Lavage du Martinet (Mines de Trélys). *Par* M. LANDRIVON, *Ingénieur des Mines du Martinet. Bulletin de la Société de l'Industrie Minérale. Ser.* 2, *Vol. XII.* 1883, *pp.* 393–437. *Four Plates.*

M. Landrivon has given a detailed account of a building constructed for the purpose of washing coal. The process is conducted on the fundamental principle that thorough cleansing can only follow on exact classification; and a large part of the apparatus employed fulfils no other object than to sort the lumps according to sizes, which determines the particular process by which they are to be freed from schist and other impurities. The largest lumps—above $2\frac{3}{4}$ in. (70 mm. in diameter)—are simply treated by hand; the next in size—between $2\frac{3}{4}$ in. and $\frac{1}{3}$ in. (9 mm.)—are washed by water in the ordinary way; while everything smaller than this is subject to a process in which crystals of felspar are used in a manner to be described below.

The raw material is sifted through a percussion-screen, and lumps of less diameter than $2\frac{3}{4}$ in., which have passed through, are lifted by a chain of buckets into a separator, which sorts them into four lots, of diameters varying respectively between (1) $2\frac{3}{4}$ and $1\frac{1}{2}$ in. (70 and 40 mm.), (2) $1\frac{1}{2}$ and $\frac{3}{4}$ in. (40 and 20 mm.), (3) $\frac{3}{4}$ and $\frac{1}{3}$ in. (20 and 9 mm.), (4) $\frac{1}{3}$ and 0 in. The first three are washed at once, and a fine residue of small fragments is carried from each by a stream of water to join lot (4), and to be subjected with it to yet another sorting process in a slime-cone, from which they issue in four directions, according to sizes determined by the following maximum diameters:—$\frac{1}{3}$ in. (9 mm.), $\frac{4}{15}$ in. (7 mm.), $\frac{1}{5}$ in. (5 mm.), $\frac{3}{17}$ in. (3 mm.), ready for the process of washing in cases containing crystals of felspar. Each case is about 4 feet (1 m. 20) in length by 3 feet (0 m. 88) in width, and has an interior lining of four sides, which are in close contact with the upper half of the exterior envelope, but slope abruptly away from the sides of the lower half to some point at the bottom, thus forming an inverted irregular quadrilateral pyramid. At this lowest point there is a small outlet for the schist. Each case is divided by a vertical partition into two compartments, into one of which water flows from a tap, and is forced by the downward strokes of a piston into the other, and upwards through the meshes of a horizontal wire frame, on which rests a layer of crystals of felspar. These cases are eight in number, and the fragments of coal and schist of a particular size are carried by a strong current of water through two in succession. As they pass over the beds of felspar, the schist, which is heavier than the coal, sinks, and ultimately finds its way through the crystals and the meshes of the frame to the outlet mentioned before, while the coal issues from the case in a state almost, but not perfectly, pure. The size of the mesh of each frame is regulated by two conditions: it must be large enough to allow an easy passage for the fragments of schist, and yet not so large as to interfere with the support of the crystals, which, to favour thorough cleansing, must be as small as possible. The thickness of the bed varies from 1 to 2 inches (30–55 mm.), a greater thickness being required as the purity of the coal approaches perfection. The piston moves at the rate of 144 strokes per minute, through a regulated distance of $\frac{1}{5}$ to $\frac{1}{3}$ in. (5 to 20 mm.), according as the fragments are small or large. Care also must be exercised with regard to the rate of egress of the schist, for this influences the force of suction to which the coal is subjected, and must be higher as the quantity of schist is larger; a more important matter still is the flow of water from the tap, on which largely depends the rate of progress of the material, and the time during which it is being operated upon. The accurate adjustment of so many details should produce a theoretically perfect result, which, however, the skill of the most experienced workmen is unable to obtain practice.

The water that escapes from the slime-cone and the cases of felspar, charged with a quantity of solid matter, finds its way first into a cistern, where the coarse particles gravitate to the bottom, while the finest, about 4,100 grains per gallon (58 grms. per litre), are carried onwards to a trough of nearly 40 feet in length, where, by the action of a screw, some 600 grains per gallon (8 grms. per litre) accumulate at one end. Each deposit, whether from the cistern or trough, is transferred into a suitable receptacle by means of a chain of buckets, where it is left to dry before being carted away.

As the water passes on from here it unites with another stream proceeding from a trough, in which has been conveyed all the schist washed out from time to time, and a last effort is made to obtain another deposit in a basin with inlet and outlet of peculiar construction. About 3,200 grs. are brought in by every gallon of water (46 grms. per litre), and 2,650 (38 grms. per litre) succeed in making an escape. The water has now done its work, and after the loss sustained on the whole round of washing operations has been made good, it is pumped up to the top of the building, and proceeds on another journey.

The writer continues with a comparison of results obtained by the use of different kinds of material in the place of the Norwegian felspar. A patriotic desire to use a native rather than an imported article, induced him to investigate the action of the felspar, and the chief essentials for a good bed. He found that the movement of the crystals is not vertical, but is confined to a small rotation about an angle, and that their action is like that of a number of valves, through which the schist finds its way by degrees, so that the most important properties are (1) a certain convenient density, determined by experience, (2) well defined rectilineal angles, and (3) great durability to resist the constant wear and tear. The first two properties are possessed equally well by quartz; and although the substance is inferior to felspar as regards durability, yet the abundance of it in the immediate neighbourhood of Le Martinet fully compensates for this drawback. Moreover, a long series of trials actually give better results when quartz takes the place of felspar, as tested chemically by the quality of the coal which passes over the bed, and of the schist which passes through. Although subject to no rigidly fixed law, yet it is found that the percentage of ash yielded by combustion varies roughly with the density of the raw material, at any rate, what is not necessarily the same thing, with the percentage of impurities. Corresponding to a density 1·4, is a percentage of ash 15·5, and everything heavier than this should, at all events, pass through the bed; but a much lower limit is desirable, and the better results obtained by the use of quartz, rather than felspar, are that the coal and schist, as separated by the former, yield on the average, respectively, 6·3 and 63 per cent. ash, compared with 7·1 and 60 per cent. when the latter is used, the greater percentage for the rejected schist being, of course, another advantage. To avoid the waste of so much combustible material as this schist contains, the cases have lately been constructed with three compartments, the third being added to receive the most useful part of the schist. Other materials have been tried in place of felspar, such as gravel, and the schist itself, but to no purpose.

In conclusion, the advantages of the whole process may be briefly enumerated as follows:—

1.—Thorough cleansing, resulting from exact classification.

2.—The recovery of the slime, which is very useful for heating boilers.

3.—The small number, four, of workmen required.

4.—The facilities for supervision and reparation, due to the intimate connection of the several parts.

No. 4, however, entails a corresponding disadvantage, viz., the difficulty of keeping one part of the machinery going by itself, especially the chain of buckets belonging

to the basins. These should continue at work several hours at the end of each day, in order to prevent the machinery being stopped by the accumulation of sediment, so that it is well worth the expense to erect a special engine for the purpose, and the same remark applies to other parts of the machinery.

Other disadvantages are—

2.—The inconvenience of readjusting the details mentioned above when any change is made in the nature of the materials to be treated.

3.—The use of a centrifugal pump, the regular action of which requires equal regularity on the part of the whole machinery.

4.—The expense resulting from the necessity of frequently renewing the iron pipes employed.

5.—The high cost of the whole installation, of which some idea may be gained when it is said that the woodwork alone amounts to more than £1,100, and the belting to about £185. W. F. P.

MINING IN BOLIVIA.

Beiträge zur Kenntniss des Bolivianischen Bergbaues. By H. Reck. *Berg- und Huettenmænnische Zeitung, Vol. XLIII., pp.* 125–126.

1.—*The Silver Mines of Portugalete.*—These mines are situated in the Department of Potosi, in the province of Chichas. The mining village stands 14,066 feet, and the mines themselves more than 15,000 feet above sea-level. The veins, which are only partially worked, occur in a porphyritic rock intrusive in Silurian beds. They strike north-east and south-west, and hade sometimes to the east and sometimes to the west. In breadth they vary from 9 inches to 6 feet. The porphyry, which consists chiefly of augite and altered felspar, contains also black hornblende and is impregnated with sulphides of zinc, iron, and copper. The veins themselves yield argentiferous galena, Pyrargyrite (ruby silver ore), Xanthoconite (sulpharsenite of silver), horn silver, and native silver in a gangue of quartz and snow-white kaolin.

2.—*The Santa Fé Mines.*—Six leagues from Portugalete. The veins worked here occur in thinly bedded coarse-grained greywacke rock; they run east and west, hade 65° to 85° to the north, and are 9 inches to 27 inches in width, the strike of the country rock being east and west, and its dip 45° to 60° to the south. The gangue of the lodes is chiefly clay slate, quartz, and calcspar, and the ores Pyrargyrite and iron pyrites, the former in nests, and more prevalent in proportion as the latter becomes scarcer.

3.—*The Pulacayo Mines.*—These are argentiferous galena workings, situated in the Cordillera de Chocaya y San Vincente. The veins occur in an oval mass of trachytic porphyry intrusive in Silurian rocks. They run east and west, hade 60° to 85° to the south, and their average width is 3 feet. G. A. L.

COPPER DEPOSITS OF SOUTH-WEST AFRICA.

Die Kupfererzlagerstätten von Südwest-Afrika. By Dr. C. Hoeffner. *Berg- und Huettenmænnische Zeitung, Vol. XLIII., pp.* 81–83, 94–96.

A summary of all that has been previously written as to the geology and copper deposits of Namaqua Land, and more especially of papers and reports by John Barrow, A. Thies, Carl Zerrenner, F. A. E. Lüderitz, and A. Wyley. The occurrence of copper ore in this part of Africa was first made known by Van der Stell, about two hundred years ago; but it is only since 1852 that the deposits have been worked. The various companies who have engaged in these operations are enumerated, and some particulars of each are given. G. A. L.

SALT OF SOUTHERN RUSSIA.

Das Salinargebiet von Südrussland. By K. M. Paul. *Verhandlungen der k. k. geologischen Reichsanstalt*, 1885, *pp.* 167–169.

The comparatively new and important salt region described is situated near the town of Bachmuth, between the Don and the Dnieper, in the Province of Jekaterinoslaw, about 130 versts (86 miles) north of the Sea of Azov, and 200 versts (132½ miles) south-east of Charkow.

Bachmuth lies about the middle of a basin of Permian rocks, from beneath which carboniferous beds, giving rise to many collieries, crop out round its margin. Near the edge of the basin the Permian series consists of limestone, sandstone, and copper-bearing Marl Slate (Kupferschiefer); towards its centre are variegated clays, gypsum and salt-clay, with layers of rock salt.

Natural brine springs had been long known in the district, but the first two borings were put down in 1872—one at Bachmuth itself, and the other at Slaviansk, about 8 miles off to the north-west. In the latter, the first salt deposit (21 feet thick) was met with at a depth of about 400 feet, and a second about half as thick, 10 feet below the first. At Bachmuth also two beds of salt were found at about the same depth, the upper 16½ feet, and the lower (the bottom of which has not been reached) at least 147 feet thick. Later on a second boring was attempted at Slaviansk, but was put a stop to by the breaking of the rods; but about the same time a hole at Brianzówka, 765 feet in depth, proved seven distinct layers of rock salt, varying from 20 to 117 feet in thickness. The thickest of these has been mined since 1881, and consists of fine, clean, massive rock salt. The salt is brought out of the mine in large blocks, and is then broken up by machinery, the greater part being reduced to powder, and a smaller portion to lumps of the size of nuts. The production in 1883 was four million puds (6,434 tons), or about thirty waggon loads a day. A fifth boring at Stupki, about 2 miles north of Bachmuth, has also struck salt beds of value, the upper 16¼ feet thick at 536 feet, and the lower of which 48 feet are known, but the base of which had not been reached at the time of writing this paper, at 562 feet. G. A. L.

CARBONIFEROUS SPIDERS.

Neue Arachniden aus der Steinkohlen-formation von Rakonitz. *By* J. Kusta. *Sitzungsberichte der K. böhm Gesellschaft der Wissenschaften. Prague*, 1885, 6 *pp. and* 1 *Plate.*

This is an account of three new species of fossil arachnids found in the Radnitz beds of the Coal-Measures of the Rakonitz district in Bohemia. The following is a list, given by the author, of all the arachnids (including the three new species described) hitherto found in the Carboniferous rocks of Bohemia:—

Order I.—*Araneæ: Palaranea borassifoliæ* Fritsch.
„ II.—*Anthracomarti: Anthracomartus Krejcii* Kusta.
„ *affinis* „
„ *minor* „
A species allied to *Kreischeria.*
„ *Architarbus.*
„ III.—*Pseudoscorpioneæ: Rakovnicia antiqua* Kusta.
„ IV.—*Pedipalpi: Thelyphonus bohemicus* Kusta.
„ V.—*Scorpioneæ: Cyclophthalmus senior* Corda.
And scorpion fragments from Nürschan and Studnoves, near Schlan.
All the rest are from Rakonitz. G. A. L.

GOLD IN CARINTHIA.

Die Goldseifen von Tragin bei Paternion in Kärnten. *By* DR. RICHARD CANAVAL. *Jahrbuch der k.k. geologischen Reichsanstalt, Vol. XXXV.*, 1885, *pp.* 105–122. *Four figures in text.*

In this paper the author describes a series of gold-bearing sands and gravels laid bare by the Weissenbach stream, not far above its mouth, on the right bank of the Drau River, in the neighbourhood of Paternion. This auriferous drift has frequently been worked in past times, remains of washing stations having been found along the south banks of the stream from Hammergraben to Duel, a distance of five or six miles. It lies beneath glacial deposits, and rests unconformably upon high-dipping and much disturbed ancient crystalline rocks (schistose and granitic chiefly), the exact geological position of which is extremely doubtful. The largest nugget found (by Baron von Gersheim) weighed 2,735 milligrammes (42·2 grains). The following Table shows the amount of gold present in the gold-drift of this district (Tragin being half-way between Hammergraben and Duel, on the Weissenbach) compared with the produce of similar deposits in other localities:—

Gold-Sand from.	Amount of Gold per Kilogramme of Sand.	Authority.
The Rhine (first kind) ...	... 0·0000562	Daubrée.
„ (second kind) ...	... 0·0000243	„
„ (third kind) ...	... 0·0000131	„
„ (fourth kind) ...	... 0·0000008	„
Tragin (maximum)	... 0·000081	Baron von Gersheim.
„ (average)	... 0·0000226	„
„ (minimum)	... 0·0000025	„
Olahpian (maximum) ...	... 0·00039	Zerrenner.
„ (average)	... 0·0000625	„
Miask (average for the mining period 1867–1875) ...	0·0000336	Sewastjanow.
The Amur district (maximum)	... 0·00081	Anosow.
„ „ (average)	... 0·00053	„
Abyssinia	... 0·000434	Karsten.
Victoria (average)	... 0·000227	Wolf.
Geelong, Adelong, and Parker	... 0·000292—0·000076	„
New South Wales	... 0·00155 —0·00311	„
The Juba River, in California	... 0·001425	Doroschin.

G. A. L.

POTASSIUM SALTS IN MECKLENBURG.

Ueber das Vorkommen von Kalisalzen in Mecklenburg. *By* — NETTEKOVEN. *Berg- und Huettenmænnische Zeitung, Vol. XLIII., pp.* 113–115.

The success of the deep boring for salt at Sperenberg and Segeberg in 1868 and 1869 drew attention to the masses of gypsum long known to occur in the neighbourhood of Lübtheen, in the Grand Duchy of Mecklenburg-Schwerin. A boring was accordingly begun in 1874, which, in 1878, at a depth of 327·14 metres (1,073 feet), struck a bed of salt, of which 150 metres (492 feet) were proved, and which began with carnallite ($KCl + 2\,MgCl + 12\,H$) beds, in the same manner as at Stassfurt. The brine procured from this hole (and from several others since put down in the district) yields a very large and valuable percentage of potassium salts. G. A. L.

MINING IN TYROL.

Der Bergbau in Tyrol. By W. KELLNER. *Berg- und Huettenmœnische Zeitung, Vol. XLIII., pp.* 321–323, 329–331.

A concise account of the geology and mines of the region comprised between the Bavarian Alps, the watershed of the Noce and Etsch, the Engadine Mountains and the Ortler Spitz, and the Upper Tauern Alps in the west. This tract of country includes North Tyrol, itself divided into two sharply-separated north and south portions, and South Tyrol. The northern half of North Tyrol consists of sedimentary rocks ranging from the Bunter Sandstone of the Trias to the Miocene Molasse, and the southern and more mountainous half, reaching as far as the Brenner Pass, forms part of the Central Alps, and like them presents a complicated mass of crystalline schists and gneisses. In Southern Tyrol are the Dolomites, from the Rienz to Stilfserjoch, and the Cevedale with sandstone, gneiss, and micaschist; then the calcareous district of the Vintschgau and the Laaserthal with crystalline marbles, serpentine rocks in the Pfitscherthal, porphyries in the Eisack district, and granite on the southern slopes of the Brenner.

Since the fifteenth century mining operations of various kinds have been carried on in these mountains for iron, copper, silver, lead, and zinc ores, gold, platinum, quicksilver, anthracite and brown coal, grünerde, and salt. The chief workings in present activity are enumerated in this paper, and very brief particulars of each are given. In North Tyrol alone there were, in the beginning of 1881, 91 concessions, distributed as follows:—

			Square Metres.	
27 for brown coal and anthracite,	covering an	area of	1,251,163	(313 acres).
11 for asphalt	,,	,,	1,302,842	(325 acres).
12 for lead ore	,,	,,	676,740	(169 acres).
16 for copper ore	,,	,,	4,644,134	(1,161 acres).
25 for gold	,,	,,	496,276	(124 acres).
Besides iron mines	,,	,,	2,300,916	(575 acres).

G. A. L.

COAL IN ITALY.

Descubrimiento de carbones en Italia. ANON. *Revista Minera y Metalúrgica. Ser. C., Vol. III., p.* 96.

Announcement of the discovery of an important coal-field at Serra-San-Bruno, in Calabria. Seven seams of coal of excellent quality have been proved by borings. The uppermost was met with at a depth of 523 metres (1,715 feet). G. A. L.

THE ALOSNO COPPER MINES IN SPAIN.

Die Kupfergrube von Alosno in Spanien. By FR. WIMMER. *Berg- und Huettenmœnnische Zeitung, Vol. XLIII., pp.* 139–142.

The Alosno Mining Concessions occupy an area of 2,540,000 square metres (635 acres) in the province of Huelva. Together they form the El Lagunazo group of mines. The chief ore deposit is a mass of copper and silver-bearing iron pyrites, similar to those of the Rio-Tinto, Tharsis, and St. Domingo mines. Its length is about 600 metres (1,969 feet), and its breadth attains 65 metres (71 feet.) It strikes east and west, and dips to the north at an angle varying from 70° to 45°. The deposit becomes broader as it deepens, and forms a huge lenticular mass of unknown depth, conformably intercalated between the bedded rocks of the district. Details of the mode of working are given. G. A. L.

PETROLEUM IN HUNGARY.

Petroleumvorkommen in Ungarn. *By* J. NOTH. *Verhandlungen der k. k. Geologischen Reichsanstalt*, 1885, *pp.* 83–85.

The occurrence of petroleum has long been known in Hungary, but, hitherto, the quantities found have not been such as to render the working of the deposits very successful commercially. All the localities known up to date are enumerated and briefly described in this paper. They are as follows:—At 3 kilometers (1·8 miles) from the village of Monostor, south-east of Nagybanya, in Szatmar county, oil in some abundance is found in a dolomitic limestone, described as underlying regularly-bedded micaschist. This is the only point in the district at which the petroleum is associated with rocks older than Neocomian.

In the counties of Sarosz, Zemplin, Unghvar, and Haromszek the oil is found impregnating rocks of Cretaceous age at the villages of Komarnik, Kriwa-olyka, Luch, and Sosmezö, but deep borings are needed to reach it.

At Közmerö-Szaczal, near Udvarhelz Zibs, 200 kilos. (440 lbs.) of oil are yielded daily by a bore-hole 200 metres (654 feet) deep in Eocene beds.

In the Neogene (Upper Tertiary) salt-bearing formation oil is stated to occur in North-eastern Marmaros, near Dragomer.

Less known deposits are some in the Nagy-Banya basin and at the foot of the Matra range. Here the oil is found strongly impregnating trachytic tuffs of Miocene age.

It should be noted that the chief oil-bearing rocks mentioned belong to the Great Carpathian-Sandstone series, the same which is so rich in petroleum in Galicia.

G. A. L.

LIGNITE OF ISTRIA.

Eocene Braunkohlenlager bei Albona in Istrien. *By* M. PRZYBORSKI. *Berg- und Huettenmænnische Zeitung, Vol. XLIII., pp.* 157, 158, *illustrated by Fig.* 11, *Plate VI.*

But little has hitherto been known respecting the occurrence of mineral fuel in Istria. Brown coal has been recorded in unimportant quantities from the following localities:—Pinguente, Mali Ert, Pedena, Punte Ubas, and Vragna, at the foot of Monte Maggiore. At Albona, however, in the Carpano Valley, in South-Eastern Istria, lignitic deposits are found which appear to be of commercial value. They occur in the lower division of the so-called *Cosina* beds of the region, a formation of Eocene age. Some fifty seams of brown coal are recognized, interbedded with bituminous limestone, but the bottom one alone is thick enough to be profitably worked. This seam has been mined for the last sixty years, is of good quality but very irregular thickness, and yielded 15,000 tons in 1863, 35,000 tons in 1872, and from 65,000 to 70,000 tons in 1884.

G. A. L.

MINERAL OILS OF ITALY.

Sui Petrolii Italiani. *By* BENEDETTO PORRO. *Gazzetta Chimica, Vol. XIII., p.* 77. *See also Neues Jahrbuch fur Mineralogie, Geologie und Palaeontologie*, 1885. *Vol. II., Referate pp.* 14, 15.

Gives analyses and other particulars (chemical rather than geological) of the petroleum from four Italian localities, namely:—Piacenza—a clear, yellow, somewhat fluorescent oil; Rivanazzuno, near Voghera—a dark fluorescent oil; Tocco Casanria—a black bituminous oil; and San Giovanni Jucarico—like the last.

G. A. L.

BRITISH CARBONIFEROUS INSECTS.

The Carboniferous Hexapod Insects of Great Britain. By SAMUEL H. SCUDDER. *Memoirs of the Boston Society of Natural History, Vol. III., pp.* 213–224. *One Plate.*

Of the insects enumerated most belong, as is always the case in beds of Carboniferous age, to the Neuroptera to which the author adds two new genera and species, viz.:—*Archæoptilus ingens* and *Brodia priscotincta*, the former from the Coal-Measures of Chesterfield, and the latter from the Staffordshire Coalfield. The Orthoptera are represented only by *Etoblattina mantidioides* (SCUDDER) and a Phasmid. *Curculioides Austicii* (BUCKLAND) is the only Coleopteron mentioned.*

G. A. L.

A NEW SEISMOMETER.

Ueber ein Neues Quecksilber-Seismometer und die Erdbeben i. J. 1883, *in Darmstadt. By* G. R. LEPSIUS. *Zeitschrift der Deutsch Geolog. Gesellschaft, Vol. XXXVI., pp.* 29–36.

The author describes and recommends an improved form of Cacciatore's mercurial seismometer. The apparatus consists simply of a circular central reservoir of mercury, surrounded by sixteen small cups to receive the overflowing quicksilver, and thus register the direction and, to some extent, the violence, of earthquake shocks. The whole is of pottery ware, in one piece, and is provided with a glass cover. Its cost is stated not to exceed 2·50 marks (half-a-crown), and it only requires 0·5 kilogrammes (about 1 lb.) of mercury.

G. A. L.

MINING INDUSTRIES OF CLAUSTHAL IN 1884.

Uebersicht der Wesentlichsten Production der Bergwerke und der Fiskalischen Hüttenwerke im Oberbergamtsbezirk Clausthal für das Jahr 1884. ANON. *Berg- und Huettenmœnnische Zeitung, Vol. XLIV., p.* 172.

The following tabular statement shows the mineral production of the Clausthal mining district for 1884, as compared with that of the previous year:—

NATURE OF PRODUCT.	AMOUNT IN TONS.		Increase + or Decrease —
	1884.	1883.	
Coal (Palœozoic)	535,277	525,112	+ 10,165
Brown coal (from newer rocks) ...	181,363	166.626	+ 14 737
Iron ore	311.505	310,283	+ 1,222
Zinc ore (from the Oberharz Mines) ..	5,480	6,191	− 711
Lead ore (from the Oberharz „) ...	14,451	15,133	− 682
„ (from the Unterharz „) ...	29,233	30,663	− 1,430
Copper ore (from the Oberharz „) ...	370	403	− 33
„ (from the Unterharz „) ...	21.429	19,955	+ 1,474
„ (from Schmalkalden „) ..	1,041	885	+ 156
Silver ore (from the Oberharz „) ...	67	96	− 29

Similar statistics respecting the metallurgical production are also given.

G. A. L.

* In the publications of the same Society are numerous papers by the same author on the Carboniferous Insects of America.

THE CLASSIFICATION OF ORE DEPOSITS.

Bemerkungen zur Classifikation der Erzlagerstätten. By A. von Groddeck. *Berg- und Huettenmænnische Zeitung, Vol. XLIV., pp.* 217-220, 229-232.

A critical examination of the various classifications of ore deposits which have been proposed by von Cotta, Grimm, J. A. Phillips, Emmons, Curtis, and others. The author's own scheme is the following :—

A.—Original Ore Deposits.

Contemporaneous with the enclosing rock or "country."

I.—Bedded Ore Deposits.

1.—Massive ore deposits.
2.—Segregations.
3.—Bedded ores.

II.—Massive Ore Deposits.

Newer than the enclosing rock or "country."

III.—Ore Deposits filling cavities.

1.—Infillings of fissures.
(*a*) Veins in massive (non-sedimentary) rocks.
(*b*) Veins in bedded rocks.
2.—Infillings of caverns.

IV.—Metamorphic Ore Deposits.

B.—Brecciated Ore Deposits.

G. A. L.

THE BUTTE MINING DISTRICT, MONTANA.

Über das Gangrevier von Butte, Montana. By G. vom Rath. *Neues Jahrbuch für Mineralogie, Geologie, und Palaeontologie,* 1885, *Vol. I., Abhandlungen, pp.* 158-168.

Butte, in Montana, is situated in latitude 46° north and 112° 31′ west longitude (Greenwich), about 46 miles south-west from the city of Helena, at a height above sea-level of 5,800 feet on the western foot of the Great Divide. Gold-washing was the first mining operation conducted in this locality. Ten years later were discovered the rich silver and copper deposits. A short history of gold mining in Montana is given, then that of the discovery of the Comstock Lode, and the other great finds of ore deposits in the State. So rapid has been the growth of the mining district of Butte that its annual production of silver had reached 1,500,000 dollars before the name of Butte City was known in Europe. There are three principal sets of lodes, occupying an area 6½ to 7 miles long from east to west, and 4 miles broad from north to south. The lodes run east and west—slightly south-west in the western portion of the region, and slightly south-east in the eastern, thus forming a line of direction somewhat convex to the north. In the more southerly lodes the hade is to the south, in the more northerly it is in the opposite direction, the middle veins being vertical.

The Clear Grit, Mountain, Gagnon, Original, Original of Butte, Anaconda, St. Lawrence, Parrot, Shakspere-Parrot, and Shonbart (Colusa, Liquidator ?) mines are working the southern group of veins. On the middle group are the Allie Brown, Lexington, Josephine, Bell, and Bell of Butte mines, and on the northern the Moulton, Alice, Magna Charta, and Valdemere mines. The minerals filling the lodes are, quartz, rhodochrosite (red manganese ore), galena, pyromorphite, cerussite, zinc blende, redruthite (copper glance), malachite, iron pyrites, mispickel, argentite (silver glance), iodyrite (iodic silver), cerargyrite (horn silver), native silver, and gold. Brief details of most of the mines enumerated above are given. G. A. L.

ALSATIAN PETROLEUM DEPOSITS.

Beitrag zur Kenntniss des Elsässer Tertiärs. By A. Andreae. *Abhandlungen zur geol. Specialkarte von Elsass-Lothringen*, 1884, *Band II. Full abstract by* — von Koenen. *Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie*, 1885, *Vol. I., Referate pp.* 287–292.

This memoir includes an account of the remarkable Oligocene petroleum districts of Sulz-unterm-Wald, in Lower Alsace, and Hirzbach, in Upper Alsace. They are described under the following heads:—

I.—*Sulz-unterm-Wald Petroleum District*, comprising beds nearly 1,000 feet thick.

(A) *Bituminous beds of Lobsann.*—The mining operations of Lobsann, between Weissenburg and Wörth, show the following section (in descending order):—1, Clay, with *Leda Deshayesiana*, 60 metres (197 feet); 2, asphalt limestone, 24 metres (79 feet), of Middle Oligocene age; then conglomerate, dolomitic limestone, with lignite beds and more thick beds of asphalt limestone; 3, alternating marls and "pitch"-sands of Lower Oligocene age.

(B) *Bituminous beds of Pechelbronn.*—These are of Lower Oligocene age, and consist of very thinly bedded, constantly alternating "pitch"-sands and marls, very similar to No. 3 of Lobsann, altogether more than 120 metres (394 feet) thick.

(C) *Petroleum-bearing beds of Schwabweiler.*—These are either Lower Oligocene entirely, or in part (above) belong to the base of the Middle Oligocene. The petroleum occurs impregnating beds of sand and sandstone which are traversed by numerous very small faults and have been proved by borings to be at least 290 metres (952 feet) thick.

II.—*Hirzbach Petroleum District.*—The beds here have some analogy, as regards fossils, &c., to those of Schwabweiler, and, like some of the latter, are referred to the lowest division of the Middle Oligocene. They consist, however, of dark-coloured clays.

The fossils found in the various deposits are in all cases enumerated, and their study leads the author to dissent from Strippelmann and others, who hold that these Tertiary deposits of petroleum are due to infiltrations from older rocks. He, on the contrary, regards them as the result of the air-proof sealing, accompanied by considerable pressure, of a lagoon and delta formation; and this view is supported by the fact that brine is common in all the rocks associated with the mineral oil; and, further, that where, as at Lobsann, their depth from the surface is small, or they are traversed by fissures, the liquid oils give place to more highly oxydised products, such as pitch, "pitch"-sand, asphalt, &c, G. A. L.

ORE-BEARING ROCKS OF ATTICA.

Über die Lagerungsverhältnisse der älteren Schichten in Attika. By H. Bücking. *Sitzungsberichte der Preussischen Akademie der Wissenschaften*, 1884, *pp.* 935–950. *Two Plates (Map and Sections).*

A general account of the stratigraphical relations of the older rocks of Attica, in the course of which the geological position of the great ore deposits of Laurium is for the first time clearly indicated. Beneath beds of Cretaceous age (including the Athens shales and Lykabettos limestone), and quite conformable to them, comes a group of altered rocks (marbles, micaschists, and clay slate), nearly 10,000 feet thick, which

forms the uppermost division of the great metamorphic series of Attica, and to which the name of Hymettos beds has been given. The Laurium ore deposits belong to this system. Beneath the Hymettos come the Pentelikon beds, of which the base is not known, and which comprise the inferior portion of the metamorphic series. These lower beds consist of the white saccharoidal marbles, so much used for statuary purposes in ancient times, and of micaceous schists again. Among these latter there occurs a mass of Serpentine, which is extremely rich in chrome-iron-ore (chromite). Another mass of Serpentine, among rocks of much later age, is known in the foot-hills of the Hymettos range.

See also abstract by TH. LIEBISCH, in the *Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie*, 1885, *Vol. I., Referate pp.* 244, 245; *and a letter and note on the subject, by* M. NEUMAYR *and* A. BITTNER *respectively*, in the same publication (*Abhandlungen* part of the same volume, pp. 151–154). G. A. L.

THE RÜNDEROTH MINING DISTRICT.

Beschreibung des Bergrevieres Ründeroth. By F. L. KINNE. 1884. *Abstract by* A. STELZNER. *Neues Jahrbuch für Mineralogie, Geologie, und Palaeontologie*, 1885, *Vol. I., Referate pp.* 49, 50.

This mining division, about 800 square kilometers in area (500 square miles), lies on the right bank of the Rhine, within the province of Cologne, and marches with that of Deutz. It forms part of the region of the Rhine slates, the greater part consisting of the Middle Devonian Lenne beds, and the rest of Lower Devonian rocks, with the exception of some overlying Tertiary, drift, and alluvial deposits.

There are five groups of lodes in the Lenne slates, very similar in character to those of Deutz, and yielding galena, zinc blende, and copper and iron pyrites. In the Lower Devonian three sets of veins are known, bearing spathose iron ore and brown hæmatites, iron and copper pyrites, galena, and zinc blende. Lastly, there are other deposits of iron ore, forming basin-shaped masses, lying upon the Middle Devonian limestones, and probably of Tertiary age.

In 1882, 1,015 miners were employed in the district, producing 20,726 tons of iron ore, 141 tons of zinc ore, 4,200 tons of lead ore, and 47 tons of copper ore.

G. A. L.

EXTENSION OF THE BELGIAN COAL-MEASURES.

Note sur le prolongement de la formation houillère au delà de la limite N.E. assignée par Dumont dans la province de Liége. By R. MALHERBE. *Annales de la Société Géologique de Belgique, Vol. X., Bulletin, pp. cxc.–cxcviii.*

In 1833 the late A. Dumont regarded the limits of the concessions of Tassin, Senzeille, Bon-Espoir, and Biquet-Gorée, as being those also of the Liége coal-field. This opinion has, up to the present time, been generally held. In 1873, however, the writer, in a memoir descriptive of that coal-field, ventured to predict that it extended considerably further in that direction, but this view met with many objections. Since that time, however, M. Malherbe, by means of borings, levels, and shafts, has proved the correctness of his surmise, and announces the proved extension of the Coal-Measures as far as Boirs, Villers-St.-Siméon, Hermée, and Harcourt, in the present paper, which is preliminary to a much fuller description of his researches. G. A. L.

THE STRENGTH OF WINDING ROPES.

Sur la Résistance des Cables de Mines. Revue Universelle des Mines, Sér. 2, Tome XVII., pp. 142—162.

A fatal accident in a mine at Hardenberg, in Westphalia, is the occasion of an investigation by M. Peters of the strength of ropes. An examination of the broken rope showed that the component wires had snapped nearly all in the same place; moreover, the cage had fallen with such even motion that the only trace of any damage to the guides was a scratch, some 18 inches in length, probably inflicted by the parachute; and, lastly, a plummer block, broken at the same time, had fallen gently instead of being violently hurled down. Such remarkable evidence points to the fact that the rope was broken by a sudden jerk, due to the fall of the cage after the machinery had come to rest; and the possibility of such an event happening is explained on the hypothesis that the engineer carelessly allowed the cage to ascend too high before slackening speed, then a sudden reversal of the engine and application of the brake would bring the rope to rest within a few inches, while the cage, in virtue of its superior momentum, would ascend several feet, causing the rope immediately to become slack, and would then descend. The problem then is to calculate through what distance the cage must fall for its kinetic energy to be sufficient to break the rope. This distance varies with the speed of ascent, and when it is known that at Hardenberg this speed was often 70 feet (20 to 24 metres) per second, and that the simplifications which are introduced into the calculations would all tend to increase the calculated speed, it must be admitted that the hypothesis is a very reasonable one. As a matter of fact, the cage contained twenty-five men, instead of the regulation number of twenty, but the effect of this irregularity on the accident is quite inappreciable. The rope was composed altogether of 190 separate wires, of differently tempered steel and iron; but it is regarded as one solid rod of the best steel, the strength of which, tested 20 feet from the point of rupture, was found to be about 66 tons per square inch (104 kilogrammes per millimetre), a loss of 20 per cent. after twelve months working, and the extension was found to be ·78 per cent. To break such a rod, the cage, with its load of men (weighing more than 7 tons), must fall 21 feet. Now, the forces acting on the rope after it becomes slack, when it is relieved of the weight of the ascending cage, are, in one direction, that due to the rotating drums and the weight of the descending cage; in the other direction, the friction of the machinery, the reversed steam pressure, and the brake. These are roughly equivalent to forces acting at the centre of the drum, one equal to the weight of 16 tons, opposed to another equal to that of 21 tons (the steam pressure being supposed equal to 5 atmospheres), hence the retardation of the rope is $\frac{5}{16}$ × that due to gravity, and if a velocity of u feet per second be destroyed in s feet,

$$u^2 = 2\,g\,\tfrac{5}{16}\,s.$$

while h, the corresponding height ascended by the cage, is given by $u^2 = 2\,g\,h$.

Now the cage must fall through a distance $h - s$, hence, putting $h - s = 21$, it is found that $u = 85$, *i.e.*, the required velocity is 85 feet per second.

This improbable figure is reduced first to 58, by taking the steam pressure nearer 6 atmospheres, as no doubt it was; then to 44, by considering that the strength of the rope and its extension at the point of rupture were probably 20 to 25 per cent. less than 20 feet higher up, where the test was made; and, further, to 42, by assuming a slightly greater coefficient of friction.

In conclusion, the writer suggests a few precautions which might be adopted to avoid future accidents:—(1) To register the speed by suitable apparatus. (2) To test the strength of several broken rope ends. (3) To use a softer metal of which, although the strength may be 30 per cent. lower, yet the extension will be three or four times greater, and hence much more work must be done to break the rope. (4) To

dispense entirely with the length of rope below the cage, the weight of which is often half that of the load itself, and adds alarmingly to the risk of an accident.

The above numerical results are still not quite satisfactory, and M. Hutzelsieder, of London, has conducted a rigorous investigation of the elasticity of such ropes, by which he comes to the conclusion that M. Peters has estimated too highly the work which must be done to stretch the rope to its full extent. The unknown variations of the coefficient of elasticity when the tension exceeds the limits of elasticity interfere with a perfectly accurate calculation, but, by keeping within known limits, M. Hutzelsieder shows that the minimum velocity necessary to produce the accident cannot be greater than 52 feet per second, and may be as low as 35. Thus, with a velocity at Hardenberg of 70 feet per second and upwards, the accident could only be a question of time. W. F. P.

PETROLEUM INDUSTRY OF THE CAUCASUS.

Exploitation du Napthe a Bakou. *By* M. Longuety. *Le Génie Civil, Vol. VII, p.* 81.
L'Industrie du Pétrole au Caucase. *By* S. Goulichambaroff. *Le Génie Civil, Vol. VII, p.* 173.

The extension of the naptha oil industry in the Caucasus has been very great during the last fifteen years. The commercial activity of the region is concentrated at Baku, a small town situate on the western shore of the Caspian Sea. The explorations are made in the peninsula of Apsheron. The natural gas issuing from the soil was the subject of adoration by the Magi when ignited; it is now turned to the more practical purposes of burning lime and refining the crude petroleum.

The geological formation is marls and contorted limestones, of miocene age. The folds form reservoirs in which the naphtha is accumulated. This rock presents no difficulty to the sinking of pits or boring of wells. Owing to the folds, it often happens that productive and non-productive holes are found closely adjacent. Previous to 1871 the oil was obtained from pit-wells, and in 1872 there were 415 of these pit-wells in operation, none of which were more than 50 feet in depth. The boring of wells is now made in American fashion, first introduced in 1871. The drilling is made either by ropes or rods, driven by small engines heated by oil or gas. The cost of a well varies from £400 to £600. The deepest well is at Balakhani, which is 714 feet down. The oil is carried by railway or 7 pipe lines to about 200 refineries at Baku. The pipe lines consist of wrought iron tubes, 8 to 10 inches in diameter, and cost about £1,200 per mile. There is about 70 miles of pipe lines, with a carrying capacity of 2,000,000 gallons of oil per day.

The crude oil is of a deep olive colour, and an average density of ·870. The crude oil is distilled at great heat in retorts, and yields:—

	Per Cent. in Crude Oil.	Density.
Light oils—benzine and gasoline	4 ...	·780
Burning oils—kerosine or petroleum ...	30 ...	·820
Residue—masoute or astatki	66 ...	·909

The residue was largely used as a fuel for stationary, locomotive, and marine boilers, but it is now utilised for the manufacture of lubricating oils. For his purpose it is heated with steam, and produces:—

	Per Cent. in Crude Oil.	Density.
Watch oil	— ...	·900
Machine oil	50 ...	·905
Cylinder oil	— ...	·915
Vaseline	— ...	·925
Tar	16 ...	—

The residue of this distillation is a tar from which dye material and a kind of rich coke is made.

The following table shows the progress of the oil industry at Baku :—

Year.	Total No. of Oil Wells Drilled.	Production of Crude Oil.	Exportation of Refined Petroleum.	Price of Crude Oil per Ton.†
		Tons.	Tons.	£ s. d.
1832	—	2,400	—	(?)
1865	—	8,900	1,610	(?)
1870	—	27,400	4,920	(?)
1871	1	22,100	(?)	(?)
1872*	2	24,700	(?)	2 5 0
1873	17	63,500	(?)	0 5 0
1874	50	78,100	(?)	0 4 0
1875	65	93,400	32,800	0 10 0
1876	101	177,000	(?)	0 5 0
1877	(?)	240,000	(?)	0 8 0
1878	(?)	320,000	102,500	0 7 0
1879	301	370,000	114,800	0 5 0
1880	(?)	400,000	127,920	0 3 0
1881	(?)	480,000	190,800	0 2 0
1882	370	607,000	210,000	0 2 0
1883	400	800,000	250,000	0 2 3
1884	600	1,430,000	363,000	(?)

* Last year of the monopoly. † *Newcastle Daily Chronicle*, of April 11, 1884.

M. W. B.

MAKING BRICKS OF COAL ASHES.

Utilisation des Escarbilles de Houille. By A. Gouvy. *Le Génie Civil, Vol. VII., p.* 84.

The cinders from the furnaces are separated over wire gauze gratings of ·2-inch and 1·4 inches. The part passing through the ·2-inch mesh is used for making bricks, the pieces passing through the 1·4-inch mesh are washed to separate the coke, and the pieces passing over the 1·4-inch mesh and the residue from the washing are led away with the slag. The small coke obtained by washing, to the amount of 4 to 5 per cent. of the coal consumed, is used in the smiths' fires, or sold for 2d. to 3d. per bushel.

The powder passed through the ·2-inch mesh is intimately mixed in a pug mill with slaked lime, in the proportion of 10 parts of cinders and 3 parts of lime. The mixture is made into bricks with a press, requiring the attention of a man and a boy. The bricks are of a deep gray colour, and air dried. They can be advantageously used for the erection of partition walls and for filling between columns, and may be also used for the facings of windows of red brick buildings.

A cubic yard of lime will make about 1,900 bricks of 9 × 4½ × 3 inches. The cost, omitting the value of the cinders, will be:—

	s. d.
Lime per 1,000 bricks	4 4
Labour	5 0
Total	9 4

The resistance to crushing of these bricks is:—

When 2 months old	...	281 pounds per square inch.	
„ 6	„	... 394	„ „
„ 12	„	... 450	„ „

M. W. B.

ON THE INFLUENCE OF RAPID FALLS OF THE BAROMETER UPON EARTHQUAKES AND ERUPTIVE PHENOMENON.

Influence des baisses barométriques brusquees sur les tremblements de terre et les phénomènes éruptifs. By M. F. Laur. *Comptes Rendus, Vol. C.*, 1885, *pp.* 289-292.*

The effect of rapid falls of the barometer upon the evolution of gas is not disputed, the three elements being the atmosphere, the internal gas (fire-damp) and the terrestrial vacuum (the mine). When there is a brisk fall of the barometer the galleries may be filled with fire-damp. This eruption is sometimes made with violence; thus, in Belgium, the end of a working place sometimes explodes like a cannon.

At the hot springs of Montrond, the effects of a fall of the barometer are as follow:— Before the fall is completed the spring begins to bubble; the production of vapours gradually increases until a column of water is thrown from 100 to 120 feet into the air; that is, a fall equal to a few inches of water may cause the production of a violent eruption more than 100 feet high, equal to a minimum pressure of about 4 atmospheres. This phenomenon appears to be due to the brisk dissociation of the mixtures of water and carbonic acid, produced by agitation at any point in the mass.

It appears therefore that if this phenomenon of dissociation be commenced, be the cause ever so small or accidental, no human force can prevent its results.

The same phenomenon may be seen in a bottle of champagne. If it is opened very gently, so as not to produce the agitation of dissociation, only a few bubbles are visible, and the liquid is at atmospheric pressure. If the bottle is closed and shaken a little, rapid dissociation takes place, the cork is blown out, and the liquid is expelled in a mass of foam.

In conclusion, it appears that in working mines any brisk rupture of equilibrium must be avoided in terrestrial gaseous mixtures. M. W. B.

* See abstract of another paper by the same author on the influence of a low barometer upon the Geyser at Monstrond. Vol. XXXII., Abs. 84.

POETSCH'S SYSTEM OF PASSING THROUGH WATER-BEARING STRATA.

Emploi de la Congélation pour l'Exécution des Travaux en Terrain aquifère et mouvant. Fonçage des puits. By J. Keller. *Le Génie Civil, Vol. VII, p.* 99.

A description of the system appears on page 39 of the Abstracts of Foreign Papers in the present volume.

The system was used on the sinking of a pit, 8½ feet in diameter, at the Emilia Collieries near Dobriluk, between Berlin and Dresden. The strata to be traversed were:—

Yellow sand	3·3 feet.
Fine white sand	6·6 „
Rough grey sand	11·5 „
Coarse siliceous sand...	3·9 „
Fine rough dry sand...	7·5 „
Rough wet sand	26·3 „
Grey rough very wet sand	19·7 „
Grey coarse and rough sand	21·3 „
Fine grey sand	11·5 „
Fine brown sand	13·6 „
Lignite	14·8 „
	140·0

A pit, 16·4 feet square, was sunk to a depth of 26 feet, and the 12 circulating tubes were placed round the circumference of a circle, 13·8 feet in diameter. It took from 12 to 15 hours to sink each tube to the depth of 100 feet.

The freezing solution was of chloride of calcium, of a density of 28° by Beaumés' hydrometer, freezing at a temperature of 30° Fahrenheit. The circulation of the solution through the tubes was made by a small force pump, 6-inch diameter and 12-inch stroke, running 30 double strokes per minute, which gave 2 quarts of the freezing mixture per tube per minute. Towards the end of the operation the number of strokes was reduced to 15.

The freezing machine used was capable of making 1,000 pounds of ice per hour. A similar machine can be erected in a shed about 30 feet square. A motor engine, of 4 or 5 horse power, was used for running the freezing machine. The apparatus was charged with 950 quarts of solution of ammonia, and the daily consumption of this liquid was about 3 quarts. The freezing machine required the attention of two enginemen and two firemen.

The sinking was commenced 53 days after the starting of the freezing machine. This work was done without any difficulty, at the rate of about 2 feet per day. The sinkers in the bottom were paid 55s. per running yard. The timbering was very light, a simple lining of deals, supported by octagonal cribs. The shaft was lined with tapered bricks, about 12 inches thick.

When the sinking and walling was completed, all the circulating tubes were removed without difficulty. The solution of chloride of lime was passed through them, heated instead of cooled. The whole of the tubes were removed with very little injury, and were quite fit for being used in another sinking by the process. The cost was estimated at:—

PLANT.

	£	s.	d.
Freezing machine, capable of making 1,000 lbs. of ice per hour...	2,000	0	0
Solution of ammonia, 970 quarts, at 1s. 2d. per quart	56	11	8
Chloride of calcium	60	0	0
Tubes, 7 to 7½ inches in diameter, 1,280 feet, at 4s. 10½d per foot	312	0	0
Tubes, 1¾ to 2 inches in diameter, 1,280 feet, at 11d. per foot ...	58	13	4
Distribution pipes	40	0	0
Lead tubes for connections, 2,700 lbs., at 1¾d. per lb.	19	13	9
Taps for connections, 26, at £1 each	26	0	0
Regulating valves of 4½ inches diameter, 4, at £4 each	16	0	0
Covers for the tubes, 12, at £2 each...	24	0	0
Bolts and iron work	40	0	0
Boring gear, &c.	300	0	0
Contingencies	47	1	3
	£3,000	0	0

ERECTION AND INSTALLATION OF THE PLANT.

Foundation for the freezing machine	£40	0	0
Erection of the same	80	0	0
Boring 1,280 feet at 9s. 9d. per foot	624	0	0
Labour and material for closing the lower part of the tubes, each £3 5s.	39	0	0
Erection of the tubes, expense of fittings	60	0	0
Contingencies	117	0	0
Total...	£960	0	0

DAILY EXPENSE OF THE FREEZING MACHINE.

Enginemen, 2, at 6s. 8d.	£0 13 4
Firemen, 2, at 3s. 4d.	0 6 8
Solution of ammonia, 3 quarts, at 1s. 2d. per quart	0 3 6
Oils, lighting and maintenance	0 2 6
Production of steam	0 16 8
Contingencies	0 3 4
Total	£2 6 0

THE TOTAL COST WOULD THEREFORE BE:—

Redemption of plant, 25 per cent. of £3,000			£750 0 0
Removal of plant			200 0 0
Erection and installation			960 0 0
Attendance on the freezing machine from July 1st, 1884, to March 1st, 1885, 240 days at £2 6s. per day			552 0 0
Sinking per running foot	£1 16 0		
Walling „	0 19 0		
Contingencies „	0 5 0		
124 Feet at	3 0 0		372 0 0
Superintendence, travelling expenses, &c.			366 0 0
Total			£3,200 0 0

or about £25 16s. per running foot.

M. W. B.

MINING IN NOVA SCOTIA DURING 1884.

Report of the Department of Mines, Nova Scotia, for the year 1884. *By* EDWIN GILPIN, JUN. 77 *pp. Halifax, N.S.*, 1885.

The following is the summary given, showing the mineral production of Nova Scotia during the year 1884, compared with that of 1883:—

		1883.	1884.
Gold	ounces	15,446	16,079
Iron ore	tons	52,410	54,885
Manganese ore	„	150	302
Copper ore	„	60	110
Lead ore	„	—	100
Antimony ore	„	—	600
Coal raised	„	1,422,553	1,389,295
Gypsum (amount exported, home consumption unknown)	tons	144,668	111,068
Building stone (amount exported, home consumption unknown)	tons	181	780
Coke made	„	44,189	40,085
Limestone	„	26,477	25,567
Grindstones, etc. (exports only)	„	155	2,200

Brief details are given respecting the nature and condition of every colliery and mine in the Colony, and a list of all papers relating to the geology and mineralogy of Nova Scotia, read during 1884, is added.

G. A. L.

ECONOMIC GEOLOGY OF INDIA.

(1) *Geology of the Lower Narbadá Valley, between Nimáwar and Káwant.* *By* P. N. Bose. *Memoirs of the Geological Survey of India, Vol. XXI., Part I., pp. 72. One Plate and three folding Maps.*

Iron ore, chiefly hæmatite, is very plentiful in this region, and iron smelting has long been its chief industry. The ore occurs:—1.—At five localities in the Kajberi (Kujberie) district, in the Bijáwar breccia, close to its junction with the Metamorphic series, at the junction of the Bijáwar and Vindhyan sandstones, and as superficial accumulations. 2.—At two localities in the Nimár district, in the planes of foliation of the Metamorphic schists, and as surface deposits over the Vindhyan series. 3.—In the Nimáwar district, abundant and rich in hollows, as surface accumulations, chiefly close to the boundary between the Bijáwar breccia and the Vindhyan rocks. 4.—At three localities in the Chándgarh district, very rich, as in Nos. 1 and 2. 5.—At two localities in the Nimánpur district, very rich, close to the fault-line between the Vindhyans and Bijáwars, and as surface deposits. 6.—At six localities in Kátkut and Barwái, occurring much in the same positions as the above, and including the Chiktimodri or Mitanderpur ore, discovered by Mr. Mitander, the Swedish metallurgist in charge of the late Bárwai works (after whom "Mitanderpur"), in the Metamorphic series, and said to be among the richest in the whole country. 7.—The celebrated Bág mines, also in the Bijáwar formation. 8.—West of Indwan, in the Ali Rájpur district, where the ore is similar in kind and position to that of Mitanderpur. 9.—Near Mohan, in Káwant, in the Nimár sandstone.

Lead and silver ores, now worked out, were formerly plentiful in the "Chándi Khan" of Jugá, in the Hoshangabad district. Galena is still found in the neighbourhood.

Copper ore has been worked in a vein in the Metamorphic series, at Tamkhán, in the Nimáwar district. It is also said to occur near Ali Rájpur.

Lime pits are worked in the Bijáwar limestone, and in the nodular limestone of the Upper Cretaceous series, but alluvial *kankar* is the principal source of supply.

Building stones are good and varied, and are obtained from the Metamorphic, Bijáwar, and Vindhyan series, the Goudwana sandstone, the Nimár sandstone, the Cretaceous coralline limestone (the best stone of the country), the Lameta limestones (also of Cretaceous age), and the Deccan trap, which yields the commonest building stones.

(2) *The Geology of the Káthiáwár Peninsula, in Guzerat.* *By* Francis Fedden. *Same publication, Part II., 64 pp. One folding Map.*

Coal, though often reported as occurring in this region, is stated by the author to be merely thin strings of coaly matter in a band of carbonaceous shale in the Jurassic Umia rocks, "not worthy of the name even of 'fuel,' as it will not support its own combustion."

Iron was formerly worked in many parts of the province. At Kantrori, near Sara, in the North, it was obtained from the ironstone bands near the top of the Umia group, and in the West—of very rich quality—from the lateritic rocks. Magnetic iron sand, derived from the traps, is found on the shore south of Gopnáth Point.

Lead and Copper.—In the Gir Hills a quartz vein in trap has yielded some galena and copper pyrites.

Lime is chiefly procured from the "miliolite," a fine oolitic limestone of very recent formation, which occupies a large portion of the alluvial area of the province.

Gypsum occurs principally in some of the Tertiary beds in the Bhávnagar State, near Naudána, in Western Halar, and about Kuranga, south of Oka Manda.

Moss agate has been worked in a vein traversing decomposed amygdaloidal trap at Khijaria, 2½ miles west of Tankára, in the Morvi State.

Building stones.—These consist of the miliolite above mentioned, and the 'Dhrangadra stone,' a light-coloured, open-grained, slightly kaolinic sandstone, very variable in texture.

(3) *Analyses of Phosphatic Nodules and Rock from Mussooree.* *By* F. R. MALLET. *Same publication, Vol. XVIII.*, 1885, *p.* 126.

The phosphatic rock and nodules, of which analyses are given in this paper, were discovered a year or two ago by the Rev. J. Parsons and Dr. Wärth. The analyses show the deposit (more especially the nodular form) to be of a high standard for the manufacture of artificial manure. The particulars are as follows:—

	Nodules.	Rock.
Phosphoric anhydride	34·70	30·16
Lime	46·42	39·21
Magnesia	·30	·55
Alumina	3·50	5·58
Oxide of iron		2·68
Soluble silica	·20	·35
Insoluble siliceous matter	9·57	16·06
Barium sulphate		
Carbonaceous matter	·98	·92
Loss on heating to 100° C.	·32	·53
Carbonic acid, sulphuric anhydride, fluorine, undetermined, and loss	4·01	3·96
	100·00	100·00

G. A. L.

INSTRUCTIONS FOR EARTHQUAKE OBSERVERS.

Programma dell' Osservatorio ed Archivio geodinamico presso il R. Comitato geologico d' Italia, con istruzioni per gli osservatori e descrizioni d' istrumenti. *By* PROF. M. E. DE ROSSI. *Instructions abstracted by* PROF. G. DEWALQUE, *Annales de la Société Géologique de Belgique, Vol. X.*, 1882-3, *Procès-Verbaux, pp. cli.-cliv.* [*This communication is translated in full in view of the absence of the original from the Institute Library, and of the interest manifested at the present time in the subject of seismometrical observations.*]

The geo-dynamic phenomena to be observed form four groups:—

1.—Phenomena relating to the circulation of underground waters.

2.—Electrical and magnetic phenomena, considered as manifestations of the internal activity of the globe.

3.—Eruptive and micro-eruptive phenomena.

4.—Seismic and micro-seismic phenomena.

The facts relating to Nos. 2 and 4 can be observed anywhere, especially in the regular observatories.

The author insists upon the importance of establishing seismic and micro-seismic observations with the help of proper apparatus in observatories, physical laboratories, and especially in mines.

The movements of the earth's crust are of four kinds:—1, shocks; 2, trêmors (*trépidations*); 3, micro-seismic undulations; 4, slow oscillations.

A shock is characterized by a very brusque motion, either vertical or horizontal, strong or weak, slow or rapid, sensible or not.

Trepidations, or tremors, are characterized by the very rapid vibration of the land, either sensible or not, lasting a certain time, and recurring after a short interval.

Micro-seismic undulations are characterized by the slowness of the movement, by its continuity and variable force. They are always insensible and last many hours, and sometimes several days.

The slow oscillations are also insensible. They produce no vibrations, but bring about a gradual displacement of the surface level.

The instruments used in observing these phenomena are seismographs, either registering or direct vision. They may be divided into four classes:—

1.—Instruments for announcing shocks.
2.—Instruments for analysing shocks.
3.—Instruments for indicating the "trepidations" of the surface.
4.—Micro-seismometrical instruments.

The first must especially indicate the existence of an earthquake and the precise time of its occurrence. The analysing instruments must, besides this, show the forms, phases, and repetitions of the shocks, especially where these attain a certain intensity.

The instructions given by the author for observing earthquakes are as follows:—

1.—Mere indication of a shock, or of distinct and prolonged trepidations.
2.—Exact time of the occurrence.
3.—Recurrence of the shocks.
4.—Kind of shock, whether vertical or horizontal.
5.—Direction of the undulation.
6.—Intensity of the motion.
7.—Duration of the motion.
8.—Direction of the first impulse.
9.—Underground noises.
10.—Extent of the shaken area.

With regard to the intensity of shocks the following conventional scale has been adopted:—

1.—Micro-seismometric shock, registered by a single seismograph, or by several seismographs of the same kind, but not affecting seismographs of other kinds; or, again, reported by a skilled observer.
2.—Shock registered by apparatus of various kinds, and felt by a small number of persons in a state of repose.
3.—Shock noticed by several persons in a state of repose, strong enough to allow its direction or duration to be estimated, and to attract public attention.
4.—Shock felt by persons in a state of activity, shaking movable objects, doors and windows, causing crackling sounds in wooden floors.
5.—Shock felt generally by all the population, shaking furniture, beds, and ringing some house bells.
6.—Shocks waking all sleepers, ringing all house bells, causing gasaliers to oscillate, shaking visibly trees and bushes, causing some frightened persons to leave their houses.
7.—Shock upsetting movable objects, ringing church bells, causing general terror, but no damage to buildings.
8.—Shock bringing down chimneys, cracking the walls of buildings, and causing a general flight of the inhabitants.
9.—Shock causing the partial or total destruction of some buildings.
10.—Shock of the most disastrous nature. Ruins, human victims, fractures and disturbance of the soil, downfall of mountain masses. G. A. L.

HATCHETTINE IN BELGIUM.

(1) *Rencontre de la Hatchetine à Seraing.* *By* R. Malherbe. *Annales de la Société Géologique de Belgique, Vol. X.*, 1882–3. *Bulletin, p. lxii.*

Notes on the occurrence of this rare "mineral tallow" in a Coal-Measure Sandstone, forming the roof of the "*Dure Veine du bure Fanny*" Seam, at a depth of 390 metres, (1,279 feet) in the Marihaye Colliery, at Seraing. The hatchettine seems to follow and be connected with numerous quartz strings which traverse the sandstone in question. The mineral has only been recorded once before from the Belgian Coal-Measures.

(2) *Sur la Hatchetite de Seraing.* *By* Prof. G. Dewalque. *Same publication, pp. lxxi.–lxxiv.*

The Espérance Colliery, at Seraing, Flémalle-Grande, several collieries in Hainault, Charleroi, and Strépy-Bracquegnies are cited as additional localities for hatchettine in Belgium, and a very full and new account of physical properties of the mineral is given. In Britain, hatchettine has been found in the Coal-Measures of Glamorganshire.

G. A. L.

ON DUST EXPLOSIONS IN COAL-MINES.

Les accidents dits "Coups de Poussière" dans les mines à grisou et les moyens de les prevenir. *By* L. Parent. *Le Génie Civil, Vol. VII., pp.* 217–219, 227–231.

I.—*Effects of Shots.*—The ignition of a certain quantity of powder placed in a hole produces many effects, which may be detailed as follows:—

1° Shattering Effects.—This potential form of energy is due to chemical action, which instantly produces a large volume of gas. The measure of the relative instantaneousness gives also the value of the powder.

2° Ballistic Effects.—This form of energy is represented by momentum given to the projected fragments. The motive power is the gaseous mass raised to a high temperature. The clouds of dust raised by these explosions are connected with the same effects produced by reflex action.

3° Calorific, Luminous, Electric, Sonorous and other Effects.—A charge of 3·5 ounces of mining powder evolves 110,000 units of heat, and produces 28 cubic feet of gas, whose temperature may be estimated at 3,300° Fahrenheit. The gaseous mass, instantaneously produced, must pass into the adjacent atmosphere. Like the piston of a gas engine, it drives back the air in both directions, flowing past the hole; it forms a cushion of carbonated gases unable to support combustion. In short, the phenomenon is like a wave whose flow and ebb is felt. The expansion continues and exhausts the gas from the material broken down by the shot. The air rushes into the relative vacuum caused by the contraction of the heated gases until the gas is diluted to the firing point. If this mixture, in passing from the place where the shot was fired, meets a burning body, an explosion will occur, producing the actual accident.

The combustion of the powder produces principally carbonic acid gas, nitrogen, water vapour and carbonic oxide, together with a little sulphurous acid. The ignition of the fire-damp produces carbonic acid gas and water vapour. If the combustion of the fire-damp produces a temperature of 1,800° to 2,000° Fahr., the loss of heat due to the cooling action of the sides will vary as the cube of the dimensions of the gaseous

sphere. The coal-dust may then take effect. If the mine is moist, and if the accident occurs in a main gallery where the air is pure and in large volume, the odds are against its propagation. If the mine is dry and dusty, the dust may intervene, and the current of pure air, very far from reducing its importance, will increase it.

II.—*Influence of Dust.*—From the experiments made by Mr. Galloway and others, it is reasonable to conclude that any explosion, occurring in any manner, in a dry and dusty mine, may be extended into its most distant workings where the presence of gas has never been suspected previously.

The examination of the dangers arising from coal-dust show that:—

1° A mixture of air and coal-dust is not inflammable at ordinary pressure and temperature. However, the high temperature of the gases produced by the explosion of a shot is more than sufficient to instantly distil some of the dust The analyses of the crusts of coke found after explosions prove that the coal so coked has lost about 25 per cent. of its volatile matter or about 7 per cent. of the weight of coal coked. Each pound of coal-dust has given off, therefore, about 2 cubic feet of gas at ordinary temperature and pressure.

2° The fineness of the dust is dependent upon the mode of transport of the coal. The produce coming to the winding shaft is generally against the current of air, and the facility with which the dust flies away will be measured by the velocity of the air and the velocity of the trains. When moving in the same direction and at the same velocity, very little dust will be raised. The dust will become finer by the further passage of trains or men. The pureness of the dust will depend upon the relative quantities of coal and stone carried.

3° The inflammation of coal-dust varies with the quantities of contained oxygen which may arise from the volatile matter or from the hygrometric condition of the coal. The percentage of oxygen varies from zero up to at least 15 per cent. The quantity of hydrogen does not greatly vary, and the ratio O : H will be the measure of the danger of the dust; this ratio is less than unity in steam and anthracite coals, and is about 3 for bituminous coals.

It is difficult to conceive that the combustion of the dust can occur without the assistance of hydrogen, or a hydro-carbon. The agent may, however, be found in the vapour of water, which is the chief agent of oxidation; indeed dry gases will not combine under the influence of the electric spark. The two phenomena may be: the decomposition of the vapour of water and the formation of carbonic acid gas. The first absorbs heat and the second produces it. In order that the reactions be continuous the vapour of the water must have a temperature of about 1,600° Fahr.

4° The relative dryness or moisture of the dust depends directly upon the quality of the current of air.

III.—*Influence of the Quantity and Quality of the Air.*—As the depth of the workings increases the air passing through them acquires a greater capacity for moisture than it had on the surface, and unless there is water in the mine, it becomes perfectly dry in all seasons. This depth will be found to vary from 125 to 250 yards. Winter increases the dryness of dry mines, and, so long as it lasts, will convert, for the time, into dry mines a large number which are otherwise habitually moist.

The volume of the air traversing a gallery will have a direct influence on the importance of the accident, especially when the air is pure. If the air has a velocity of 500 feet per minute it will have a proportionately increased power of propagation over air at a lower velocity.

IV.—*Influence of the Current at the Place of the Accident.*—Explosions of dust rarely take place at the face of a drift, because the dust is rarely found in large quantities in the newer districts of the mine; and again, the air is immediately reversed

and returns by a parallel route. The explosion occurs in almost still air and is not easily carried elsewhere. When an explosion occurs in almost stagnant air its effects rarely extend beyond 4 to 8 yards. If it occurs in a gallery where the air circulates with a velocity exceeding 400 feet per minute, the explosion may be propagated elsewhere and sometimes may extend over all the mine.

V.—*Precautionary Measures.*—The dust must be rendered inoffensive by an abundant use of water. The use of water in the galleries must be rejected as it is only palliative. Apart from the expense, its use would require special education, or otherwise, the special danger of the increase of the transmitting power of the dust would ensue. The same remark is applicable to the chlorides of calcium or sodium, and sweeping is only palliative.

The best remedy is to prevent dryness: the mine must be made humid without inconvenience to the workmen. Take the case of a mine in which the temperature of the working face is 70° Fahr. During the summer the air descending the pit may have a temperature of 60° when it passes into the mine; it is also saturated with water vapour owing to the percolations from the sides of the pit. The temperature rises as the air approaches to the face, where it attains its maximum. During the winter the same current may have an initial temperature of 32° Fahr., or even lower, at the bottom of the pit; it then traverses the same galleries to the working face, where it attains the same temperature of 70° Fahr. It is evident that the air in the winter must be dryer than in the summer at every point of its route.

The temperature should be taken every day at the bottom of the pit, in order to ascertain the quantity of water required to saturate the air and the point or points at which the air acquires in the mine a temperature of 60° Fahr., and which may be named the zone of equilibrium. Thus, if the volume of air be 60,000 cubic feet per minute, area of the pit 100 square feet, velocity of the air 600 feet per minute, temperature 32° Fahr., and temperature acquired on entering the mine 60° Fahr., the weight of water required per 1,000 cubic feet of air would be (·82 − ·31 =) ·51 pounds, 30·6 pounds will be required per minute, or 4,406·4 gallons per 24 hours.

The remedy, therefore, appears to be to supersaturate the air with moisture. Owing to its velocity, the air can, if the liquid is applied in the form of spray or mist, carry this excess of moisture a considerable distance into the mine. Two results would be obtained: the dust would be thrown down, and the air rendered more wholesome.

Experiments would be made to ascertain at what pressure the jet should work, so that the current of air should carry the spray as far as the zone of equilibrium, and that the air at this point should be saturated. In the worst case, with absolutely dry air, 49·2 pounds of water might be required per minute, or 7,084·8 gallons per day.

If blown-out or fast shots cannot be prevented they may be made inoffensive. Accidents have been caused by the ventilation being diminished at nights, and the practice should be discontinued. The danger may be reduced to a minimum by the artificial creation of an atmosphere supporting combustion badly or relatively still at points where the shots are fired.

The atmosphere not capable of sustaining combustion may be created by burning, without deflagration, a body forming a plug of carbonic acid gas. The shot should be fired by electricity whilst this plug is passing over it. The use of dynamite reduces the danger, as there is almost no risk of blown-out shots with it. The reduction of the velocity in the place where the shot is to be fired is a useful precaution, as it greatly diminishes the risk of the propagation of the flame. M. W. B.

INDEX TO VOL. XXXIV.

"Abs." *signifies Abstracts of Foreign Papers at end of the Proceedings.* "App." *Appendix.*

Abstracts of Foreign Papers, end of Proceedings.

Account of the experiments made at the König Colliery at Neunkirchen (Saarbrücken), particularly those on the consequences which arise when coal-dust and gas come in contact with shots, and other matters intimately connected with those experiments; translated by Theo. Wood Bunning, 199.—Introductory remarks, 199.—Table showing comparative results of experiments with coal-dust from various pits, 206.—Results of experiments without coal-strewing, 209.—With coal-strewing, 210.—Summary of results, 213.—*Section 1:* General remarks respecting experiments on coal-dust, 215.—*Section 2:* The management of the experiments, 221.—*Section 3:* Description of the buildings in which the experiments were made, 223.—*Section 4:* Results of the experiments, 226.—Table comparing the results with clay stemming and coal-dust stemming, 232.—Analysis of the ash and water-free substances of the different sorts of coal-dust, 233.—Results of trials with the Pieler and Davy lamps, paper discussed, 245.—Further experiments, 297.—Further discussion, 299.

Plate.—38. Plan, elevation, and sections of the gallery used for the experiments.

Accounts, xii.

Advertisement, xi.

Africa; copper deposits of, abs. 60.

Alabama coal-fields, abs. 23.

Algerian iron ores, abs. 13.

Alosno copper mines in Spain, abs. 63.

Alsatian petroleum deposits, abs. 67.

ANALYSES: Formosa coal, 76.—Ores of San Pietro, 150.—Coals from the Dutch East Indies, abs. 43.—Iron ores of Virginia, abs. 21.—Virginian pyrites, abs. 25.

Andaman Islands; mineral resources of, abs. 14.

Apatite, Canadian, abs. 23.

APPARATUS: Electric lighting (see *Principles of electric lighting.*) For relighting safety-lamps. (See *Wolf safety lamp.*)

Arlberg tunnel; temperature in the, abs. 35.

Associate members, xxxii.

Attica; ore-bearing rocks of, abs. 67.

BAINBRIDGE, EMERSON; On a new calculator for working out "cost of working, &c.," 139.

Balloting list, lvii.

Barometer; influence of rapid falls of, on earthquakes, &c., abs. 72.

Barometers; note on the variation sometimes noticed in difference of the simultaneous readings of two barometers, one at bank and the other in the workings of a mine, 142.

Barometer readings, 309.

Belgian phosphates, abs. 36.—Manganese deposits, abs. 37.—Coal-measures; extension of, abs. 68.

Belgium; new mining regulations of. (See *Mining regulations.*) Hatchettine in, abs. 78.

Bilbao iron ore district, paper discussed, 190.

BIRD, W. J.; On a new system of coal-getting. (See *New system.*)

Blast furnace gases; heating by, 12.

Boiler flues, corrugated, abs. 7.

Bolivia; mining in, abs. 60.

Brazil; minerals associated with diamonds in, abs. 38.

Brazilian diamond deposits, abs. 45.

Breccia-gashes; Prof. Lebour's paper discussed, 167.

Bricks made of coal-ashes, abs. 71.

British carboniferous insects, abs. 65.

Brittany; tin deposits of, abs. 45.

BROWN, M. WALTON; On the Marsaut lamp, 161.—Paper on earth-shakes discussed, 168.—New mining regulations of Belgium, 265.

Brown-coal mine near Dux, abs. 5.

Building stones; Hungarian, abs. 32.

BUNNING, THEO. WOOD; experiments with coal-dust. (See *Account of.*)—On the Pieler lamp. (See *Pieler lamp.*)—On the Wolf safety lamp. (See *Wolf lamp.*)

Burnett's patent roller mining wedge. (See *New system of coal-getting.*)

Butte mining district, Montana, abs. 66.

Bye-laws, xlv.

Calculator (new) for working out "cost of working," "selling prices of coal," per ton, percentages, &c., by Emerson Bainbridge, 139.

Plate.—19. Drawing of the instrument.

Californian geology, abs. 18.

Canadian apatite, abs. 23.

Caratal gold-fields, Venezuela, abs. 46.

Carboniferous rocks of Cumberland and North Lancashire, in Furness, by J. D. Kendall, 125.—Development, 125.—Lower limestone shale, carboniferous limestone, and Yoredale rocks, 125.—Description of the formation as exhibited by the sections, 126.—Section, 128.—Aggregate thickness of Yoredales, 129.—Correlation of the limestones and Yoredales of the two districts, 130.—Millstone grit and coal-measures.—Various names by which the lowest seam of coal is known, 131.—Depth of seams of coal, 132.—Division of the carboniferous system, 135.—Concluding remarks, 136.

Plates.—13, 14, 15, 16. Sections showing the positions of the strata at various places.—17. Map of the district described.—18. Sections showing continuation of base of carboniferous rocks.

Carboniferous spiders, abs. 61.—Insects, abs. 65.

Caucasus; petroleum industry of the, abs. 70.

Charter; copy of, xxxix.

China; Formosa coal-fields. (See *Notes on.*)

Classification of ore deposits, abs. 66.

Clausthal; mining industries of, in 1884, abs. 65.

COAL: Cumberland and North Lancashire. (See *Notes on mining.*)—Brown coal mine near Dux, abs. 5.—The origin of, abs. 16.—The Choi, abs. 18.—New Zealand, abs. 34.—Metamorphism in, abs. 37.—Dutch East Indies; analysis of, abs. 43.—Price of, at St. Etienne, 1884–5, abs. 50.—In Hungary, abs. 57.—In Italy, abs. 63.

Coal-ashes; bricks made of, abs. 71.

Coal-dust; experiments at Neunkirchen. (See *Account of.*)—Explosions in coal-mines, abs. 78.

COAL-FIELDS: North Formosa. (See *Notes on.*) — Raigarh-Hingir, abs. 15.—Langrin, abs. 16.—Umaria, abs. 16.—Pennsylvanian, abs. 21.—Alabama, abs. 23.—South of France (concealed) abs. 24.—Northern and Pas-de-Calais, abs. 26; Spanish, abs. 36.

Coal-getting; new system of. (See *New system.*)
Coal-measure insects, abs. 17.
Coal-measures; Belgian, extension of, abs. 68.
Coal-washers; Felspar, abs. 58.
Cochin China; geology of, abs. 20.
Coke; price of, at St. Etienne, abs. 50.
Coke-ovens; improvements in, abs. 11.
Colorado; iron ores of, abs. 26.
Compression ventilation of a mine by means of a Guibal fan placed underground, abs. 49.
Contents of volume, v.
Copper in Luxemburg, abs. 13.
Copper belt of South Mountain, Pennsylvania, abs. 24.
Copper deposits of South West Africa, abs. 60.
Copper-lixiviation; cost of, in Baláu, abs. 4.
Copper mines in Spain, abs. 63.
Corinthia; gold in, abs. 62.
Corrugated boiler-flues, abs. 7.
Council report, vii.
Cumberland; mining in. (See *Notes on*, &c.)—Carboniferous rocks of. (See *Carboniferous.*)
Cymmer Colliery; electric lighting at, 52.

Daglish, John; notice of a new thermometer indicator, 142.
Dakota; tin in, abs. 43.
Diamond; minerals associated with, in Brazil, abs. 38.
Diamond deposits; Brazilian, abs. 45.
Drill-holes; tamping with plaster-of-Paris, abs. 29.

Earth-shakes; discussion on, 167, 168.—Letter from Prof. Ewing, 168.
Earthquake observers; instructions for, abs. 76.
Earthquakes, &c.; influence of rapid falls of the barometer on, abs. 72.
Economic geology of India, abs. 75.
Election of members, 1, 65, 143, 173, 191, 263.
Electric lighting. (See *Principles of.*)
Electric machinery in mines, abs. 5.
Endless chain in Spain; paper discussed, 190.
Eppleton Colliery; electric lighting at, 54.
European iron ores and their origin, abs. 33.
Ewing, Prof.; letter on earth-shakes, 168.
Excursion to the Hury reservoir, 255.
Experiments: Shrinkage of paper, 175.—Routledge and Johnson lamp, 187.—Compression of fossil fuels, abs. 46.—Coal-dust, 199.—Lamps at Pelton Colliery, 293.
Explosions: Coal-dust experiments. (See *Account of* and abs. 78.)

Felspar coal-washers, abs. 58.
Finance Committee's report, x.
Fire-clay; Hungarian, abs. 23.
Fire-damp; indicating, 285.
Foreign papers; abstracts of, end of proceedings.
Formosa coal-fields. (See *Notes on.*)—Fossils, 81.
Forms, lii.
Fossil fuels; experiments on the compression of, abs. 46.
Fossils; North Formosa, 81.
Freezing as applied to sinking operations, abs. 72.
Fuel; patent manufacture of, abs. 30.
Furness; mining in. (See *Notes on.*)—Carboniferous rocks of. (See *Carboniferous.*)

Galloway, W.; On experiments with coal-dust, 245, 300.
Gas detector. (See *Pieler lamp.*)
General statement of accounts, xvi.
Geology: Californian, abs. 18.—Cochin China, abs. 20.—Tasmania, abs. 32.—India, abs. 75.

GOLD: In Queensland, abs. 44.—In Norway, abs. 46.—In Corinthia, abs. 62.
Gold-fields: Caratal, abs. 46.
Gold-mines of Guadalajara, abs. 31.
Guibal fan underground, abs. 49.
GUNN, WILLIAM; report, Hury reservoir, 255.

HALSE, EDWARD; On the manganese deposit of San Pietro. (See *Manganese deposit*.)
Hatchettine in Belgium, abs. 78.
Haulage by electricity, abs. 6.
Heating by blast furnace gases, abs. 12.
Hilt, Herm; experiments with coal-dust, 199.
Honorary members, xviii.
Hungarian fire-clay, abs. 23.—Building stones, abs. 32.—Coal, abs. 57.—Petroleum, abs. 64.
Hury reservoir; excursion to the, 255. *Plate.*—39. Section of the line of embankment.

India; economic geology of, abs. 75.
Insects; coal-measure, abs. 17.—British carboniferous, abs. 65.
Instructions for earthquake observers, abs. 76.
Inversion of strata, abs. 14.
Iridium industry, abs. 29.
IRON; Cumberland and North Lancashire. (See *Notes on.*)
Iron mines of Palmesalade, abs. 33.
Iron mountain of Durango, in Mexico, abs. 57.
Iron ores; Algerian, abs. 13.—Virginian, abs. 21.—Eastern States, abs. 22.—Colorado, abs. 26.—European, and their origin, abs. 33.
Iron and silver in Mexico, abs. 25.
Iron and steel; testing of, abs. 13.
Istria; lignite of, abs. 64.
Italy; quicksilver in, abs. 52.—Coal in, abs. 63.—Mineral oils of, abs. 64.

Java; underground temperature in, abs. 42.
Johnson; safety lamp. (See *Routledge and Johnson.*)

KENDALL, J. D.; On mining in Cumberland and North Lancashire. (See *Notes on*, &c.)—On the carboniferous rocks of Cumberland and North Lancashire, or Furness, 125.

Lancashire; mining in. (See *Notes on.*)—Carboniferous rocks of. (See *Carboniferous.*)
LEACH, C. C.; On the shrinkage of paper. (See *Shrinkage.*)
Lead and copper; Cumberland and North Lancashire. (See *Notes on Mining.*)
LEBOUR, G. A.; notes on some fossils from North Formosa, 81.—Paper on Breccia-gashes discussed, 167.—On the manganese deposit of the islet of San Pietro, Sardinia (communicated), 145.
Life members, xviii.
Lignites; Styrian, abs. 14.—Ráipur, abs. 17.—Istria, abs. 64.

Magnetic needle; ore-seeking with the, abs. 35.
Manganese deposit of the islet of San Pietro, Sardinia, by Edward Halse, 145.—Description of the island, 145.—Strata, 146.—Analyses of ores, 150.—Table showing occurrence of manganese ore in other parts of Sardinia compared with the San Pietro bed, &c., 151.—Origin of the deposit, 152.—Mode of Exploitation, 153.—History, 155.—Production from 1854-1883.—Workmen employed, wages, &c., 156.—Future exploitation, 157.—Notes on microscopic sections of the rocks, 159.
Plates.—20. Map showing the volcanic rocks of the south-west of Sardinia.—21. Sections of trachyte rocks.—22. Longitudinal section.—23. Plan of a portion of the workings of the Capo Rosso mine.

Manganese deposits; Belgian, abs. 37.
Manilla hemp winding ropes, abs. 55
Manufacture of patent fuel, abs. 30.
MARGRAF, HERR; experiments with coal-dust, 199.
Marsaut lamp; On the, by M. Walton Brown, 161.—Discussed, 165.
Plate.—24. Drawings of the lamp, showing Ryder's improved fastening.
Mecklenburg; potassium salts in, abs. 62.
MEMBERS: Honorary, xviii.—Life, xviii.—Original, xx.—Ordinary, xxxi.—Associate, xxxii.—Students, xxxvi.—Subscribing firms, &c., xxxviii.
MERIVALE, PROF.; On the variation sometimes noticed in the difference of the simultaneous reading of two barometers, one at bank and the other in the workings of a mine, 142.
Metamorphism in coal, abs. 37.
Mexico; silver and iron in, abs. 26.—Iron mountain of Durango, abs. 57.
Mineral imports and exports of Spain, abs. 38.
Mineral oils of Italy, abs. 64.
Mineral resources of the Andaman Islands, abs. 14.—Of the Tinnevelly (Madras), abs. 15.—Afghan frontier, abs. 17.
Minerals associated with diamond in Brazil, abs. 38.
Minerals (useful) of New Zealand, abs. 19.
MINING: in Cumberland and North Lancashire. (See *Notes on.*)—In the Bukowina, abs. 51.—In Bolivia, abs. 60.—In Tyrol, abs. 63.—In Nova Scotia in 1884, abs. 74.
Mining districts: the Yauli, abs. 52.—Butte, Montana, abs. 66.—Ründeroth, abs, 68.
Mining industries of [illegible]asthal in 1884, abs. 65.
Mining produce of Dortmund in 1883, abs. 1.—In 1884, abs. 53.
Mining regulations of Belgium (new), translated by M. Walton Brown, 265.—Keeping plans of mines, 265.—Shafts, 266.—Descent and ascent of workmen, 267.—Ventilation, lighting, and use of explosives, 268.—General ventilation.—Fiery mines, 269.—Lighting of fiery mines, 271.—Use of explosives, 273—Accumulations of water, 274.—Control of workmen, 275.—Special examination of workings in fiery mines, 276.—Temporary arrangements.—Prevention of accidents.—Rules to be followed on the occurrence of accidents, 277.—General rules, 279.—Appendix, 279.
Nevada; silver-lead deposits of, abs. 31.—Nickel and cobalt in, abs. 39.
New system of coal-getting, with Burnett's patent roller mining wedge and nicking machine, by W. J. Bird, 193.—Description of the machine, 194.—Mode of working, 195.—Supplementary remarks, 197.
Plate.—37. Drawings of the machine and plan of nicking.
New Zealand; useful minerals of, abs. 19.—Coal, abs. 34.
Nickel and cobalt in Nevada, abs. 39.
Nomination of members; forms of, lii.
Norway; gold in, abs. 46.
Notes on the coal-fields and coal-mining operations in North Formosa (China), by David Tyzack, 67.—Aspect of the country, 67.—Fossils, 69.—General deductions, 69.—Visits to native mines, 71.—Thickness of coal-seams and dip of strata, 72.—Character of the native workmen.—Ideas of the native officials on the proposed mining operations, 73.—Strata sunk through, 74.—Wages, output, &c., 75.—Analyses of the coal, 76.—Discussed, 77, 190.
Plate.—12. Map of the island of Formosa.
Notes on some fossils from North Formosa, by Professor G. A. Lebour, 81.

Notes on the history of mining in Cumberland and North Lancashire, by J. D. Kendall, 83.—Iron: history traced upwards from the time of the Ancient Britons, 83.—Names of companies working ores in Furness at different periods, 93-98. — Production of iron ore, 1841-1882, 97. — Coal: history traced from the time of the Romans, 100. —Seams worked at different periods, 102.—Exports, 1781-1792.—Description of a winding engine at work in 1805, 108.—Workington colliery flooded, 111. —Produce of coal in Cumberland. 1840-1882, 114. — Companies working coal in 1884.—Number of persons employed, 115. — Lead and copper, &c., 116-124.

Notes on microscopic sections of rocks from San Pietro, Sardinia, by F. W. Rudler, 159.

Nova Scotia; mining in, in 1884, abs. 74.

Officers, xix.

Ordinary members, xxxi.

Ore-bearing rocks of Attica, abs. 67.

Ore deposits; classification of, abs. 66.

Ore-seeking with the magnetic needle, abs. 35.

Organic matter forming in a coal-pit, abs. 22.

Original members, xx.

Paper; shrinkage of. (See *Shrinkage.*)

Patent fuel; manufacture of, abs. 30.

Patrons, xvii.

Pelton Colliery; experiments with lamps at, 293.

Pennsylvanian coal-fields, abs. 21.—Copper belt of South Mountain, abs. 24.

Persia; turquoise mines of, abs. 19.

Peru; Yauli mining district in, abs. 52.

Petroleum in Hungary, abs. 64.—Deposits in Alsatia, abs. 67.—Industry in the Caucasus, abs. 70.

Phosphates: Belgian, abs. 36.

Pieler lamp, and modes of indicating the presence of small quantities of fire-damp in mines, by T. W. Bunning, 285.—Description of the lamp and apparatus, 285.—Table, showing results of observations on the ventilation of the Gouley Mine for a month, 288.

Plate.—40. Drawings of the lamp and apparatus.

Pit shafts; form and arrangement of, abs. 8.

Plaster of Paris; tamping with, abs. 29.

Pneumatic despatch tube between London and Paris, abs. 41.

Poetsch's system of passing through water-bearing strata, abs. 39, 72.

Potassium salts in Mecklenburg, abs. 62.

Principles of electric lighting, and the construction and arrangement of electric light apparatus, by Sydney F. Walker, 3.—Conductors, 3.—Resistance, current, circuit, electro-motive force, 4. Definition of terms, methods of generating electricity, 5.—*Machines*, 7.—The Gramme, 8.—Siemens, 10.—Maxim, 11.—Weston, Edison, Bürgin, Gülcher, 12.—Schuckert, Brush, 13.—Elphinstone-Vincent, alternating-current, 17. —Alliance, De Meritens, Gramme alternating, Siemens alternating, Ferranti-Thompson, 18.—Permanent and electro magnets, 19.—The Series dynamo, 20.—Shunt dynamo. 21. — Two types of Gramme machine, 23.—*Electric lamps*, Arc, 25.—Crompton, 27.—Brockie, Siemens pendulum, 28.—Clutch, Brush, and Weston, 30.—Brockie commutating, 33. —Lever, 35.—Motor, 36.—*Purely electrical lamps*, the Pilsen, Gulcher, 37.—Sun, Electric candles.—*Incandescent lamps*, 39. — Swan, 40. — Lane-Fox, Crookes, Woodhouse, and Rawson, 42.—Connections, 42. — Insulation, 44.—Installation at Cymmer Colliery, 52.—Automatic regulator, 53.—Installation at Eppleton Colliery, 54.—Switches, 54.

—Holders, automatic cut-outs, 55.—Fusible cut-outs, measuring instruments, 56.—The engine or mechanical motor, 57.—Faults, 58.—Appendix, secondary batteries or electrical accumulators, 60.—Discussed, 62.

Plates.—1, 2, 3, 4, 5, 6. Drawings of machines, cores, bobbins, and illustrations of various sytems of making connections.—7, 8, 9, 10. Drawings of lamps, commutators, clutches, switches, &c.—11. Plan of connections of the incandescent electric lights at Eppleton Colliery.

Prussia; mining produce of Dortmund in 1883, abs. 1.—In 1884, abs. 53.

Prussian commission on coal-dust, 199.

Pulsometer; the, abs. 7.

Pyrites; Virginian, abs. 25.

Queensland; gold in, abs. 44.

Quicksilver in Italy, abs. 52.

REPORTS: Council, vii.—Finance committee, x.

Routledge and Johnson double combination miner's safety lamp, by J. Routledge, 183.—Description of the lamp, 185.—Results of experiments, 187.—Lighting power, 188.—Discussed, 188.

Plates.—35, 36, 37. Showing construction of the lamp.

Royal Charter, xxxix.

RUDLER, F. W.; notes on microscopic sections of rocks from San Pietro, 159.

Rules, xlv.

Ründeroth mining district, abs. 68.

Russia; Southern, salt of, abs. 61.

RYDER, W. J. A.; improved fastening to the Marsaut lamp, 162; and *Plate* 24.

SAFETY-LAMPS: Marsaut, 161.—Routledge and Johnson, 183.—Weights, &c., of various, abs. 50.—Pieler, 285.—Wolf, 291.

Salt at Salies, abs. 14.—In the Soudan, abs. 51.—Of Southern Russia, abs. 61.

Sardinia; manganese deposit of San Pietro. (See *Manganese deposit.*)

SECTIONS: Strata at Kelung, Formosa, 74.—Cumberland and North Lancashire, or Furness' coal-field, 128, and *Plates* 13–16, and 18.—Trachyte rocks, San Pietro, 159; *Plates* 21, 22.—Line of embankment, Hury reservoir, *Plate* 39.

Seismometer; a new, abs. 65.

Shaft and winding machinery at the Bockwa-Hohndorf-Vereinigtfeld Colliery, abs. 8.

Shafts; form and arrangement of, abs. 8.

Shrinkage of paper; On the, by C. C. Leach, 175.—Results of various experiments, 175.

Plates.—25–33. Illustrating the experiments.

Siemens-Martin process; notes on, abs. 10.

Silver and iron in Mexico, abs. 25.

Silver-lead deposits of Nevada, abs. 31.

Spain; mineral imports and exports of, in 1883, abs. 38.—Alosno copper mines, abs. 63.

Spanish coal-fields, abs. 36.

STATISTICS: Production of iron, output of coal, &c., in Cumberland and North Lancashire. (See *Notes on the history of mining.*)—Mine produce of Dortmund in 1883, abs. 1; in 1884, abs. 53.—Underground haulage by locomotives and electricity, abs. 6.—Wages and prices in the Pas-de-Calais coal-field, abs. 26.—Manganese of San Pietro, 1854–83, 156.—Imports and exports of Spain in 1883, abs. 38.—Prices of coal and coke at St. Etienne, 1884-5, abs. 50.—Oil industry of Baku, abs. 71.

Soudan; salt in the, abs. 51.

Spiders; carboniferous, abs. 61.

St. Etienne; prices of coal and coke at, 1884–85, abs. 50.

STANFORD, W. H. C.; paper on the Hury reservoir, 258.

Strata; inversion of, abs. 14.
Steel; testing of, abs. 13.
Strength of winding ropes, abs. 69.
Students, xxxvi.
Styrian liguites, abs. 14.
Subscribing collieries, xxxviii.
Subscriptions, xiv.

Tamping drill-holes with plaster of Paris, abs. 29.
Tasmania; geology of, abs. 32.
Temperature in the Arlberg tunnel, abs. 35.
Testing of iron and steel. abs. 13.
Thermometer indicator; notice of, by John Daglish, 142.
Tin in Dakota, abs. 43.—Brittany, abs. 45.
Tinnevelly; mineral resources of the, abs. 15.
Trachyte rocks, 145.
Treasurer's accounts, xii.
Tunnel; Arlberg, abs. 35.
Turquoise mines of Persia, abs. 19.
Tyrol; mining in, abs. 63.
TYZACK, DAVID; On the Formosa coal-fields. (See *Notes on.*)

Underground temperature in the Arlberg tunnel, abs. 35.—In Java, abs. 42.

VENTILATION: Auxiliary, for gassy pits, abs. 3.—Compressed, by means of a Guibal fan underground, abs. 49.—Observations at the Gouley pit, 288.
Virginia; iron ore of, abs. 21.—Pyrites, abs. 25.

WALKER, SYDNEY F.; On electric lighting. (See *Principles of.*)
Water-bearing strata; Poetsch's system of passing through, abs. 39, 72.
Winding ropes; flat manilla hemp, abs. 55.—Strength of, 69.
Wolf safety lamp, by T. W. Bunning, 291.—Description of the lamp and apparatus for filling, 291.—Table showing result of experiments at Pelton Colliery, 294.
Plates.—41. Lamp and lighting apparatus.—42. Filling apparatus.
Workington Colliery flooded, 111.

Yauli mining district in Peru, abs. 52.

NEWCASTLE-UPON-TYNE: ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.